S. A. E. JOURNAL

Published by the SOCIETY OF AUTOMOTIVE ENGINEERS, INC., 29 *W. 39th St., New York*

Issued monthly, $1 a number, $10 a year; foreign $12 a year; to members, 50 cents a number, $5 a year. Entered as second-class matter, Jan. 14, 1928, at the post office at New York, N. Y., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized on Jan. 14, 1928.

W. R. STRICKLAND, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

Vol. XXIV June, 1929 No. 6

CONTENTS

General Design and Research

Effect of Gum in Gasoline—V. Voorhees and J. O. Eisinger 584
Dual Carburetion and Manifold Design—F. C. Mock 593
Better Chassis Lubricant—C. W. Spicer 604
Economic Fuel-Volatility and Engine Acceleration—Donald B. Brooks 609
Automotive Research 626
Standardization Activities 636
Notes and Reviews 672

Production Engineering

Aluminum for the Automotive Industry—Zay Jeffries 617
Production Engineering 633

Transportation Engineering

Applying the Motor-Vehicle to Business—W. F. Banks 621
Transportation Engineering 652

Aeronautic Engineering

Air and Ground Transportation Compared—L. M. Woolson 575
Aeronautic Engineering 655

News of the Society

Summer Meeting Announcement 567
News of Section Meetings 570
Chronicle and Comment 574
Personal Notes of the Members 667
Obituaries 668
Applicants Qualified 669
Applicants for Membership 671

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

The simple, compact Bendix Drive (shown full size) is the connecting link between the starting motor and the engine

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TO START a car equipped with a Bendix Drive, the only physical effort is to touch the starter button lightly. The Bendix Drive *automatically* engages the engine and cranks it. The Bendix Drive then *automatically* lets go as the engine starts. And the Bendix Drive *automatically* protects the starting system from damage if the starter button is accidentally touched while the engine is running.

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EAST ORANGE, N. J. WALKERVILLE, ONT.
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BENDIX

S. A. E. JOURNAL

Vol. XXIV June, 1929 No. 6

Final Summer Meeting Program Released

Reservations Reach 600 Mark on May 23—Inter-Section Outboard Motorboat Race to Be a Feature at Saranac

REALIZING that all S.A.E. meetings should be conducted along sound engineering lines, a chart of the total reservations received has been plotted against days before the meeting. This curve, which passed the 600 mark on May 23, indicates that the hotel capacity will be reached on June 10. A reservation mailed or telegraphed at once may beat the curve! Otherwise you may find yourself enjoying an unexpected camping trip in the Adirondacks. But, as Clayt Hill said, in the *Detroit Supercharger*, "After all, who cares? It's an S.A.E. Summer Meeting and we only use the hotel to sleep in, and not much of that. The darned thing would be a success if we held it in Byrd's Little America, just so long as the S.A.E. crowd was there and the ice held up."

Inter-Section Motorboat Race

As a result of the Milwaukee Section challenge, representatives of Sections disputing the fact that Milwaukee is champion when it comes to outboard motorboat racing are in line for a thrill. Engineers who have piloted an 8-ft. boat weighing about 100 lb. and driven by a 30-hp. engine at 50 m.p.h. in a choppy sea will appreciate Major Segrave's statement that his 88 m.p.h. in his speedboat seemed infinitely faster than his 231 m.p.h. on the Daytona sands. An extra half-inch movement of the tiller will also demonstrate, to the utmost satisfaction of the spectators, what a 2½ somersault is at 50 m.p.h.

The Milwaukee Section has such faith in the ability of its representative in piloting outboard motorboats that it is bringing necessary engines and boats to the meeting so that each Section entering a pilot may have an opportunity to dispute the challenge on equal terms.

To assure all Sections fair play, the Meetings Committee, at the request of the Milwaukee Section, has appointed a Regatta Committee, of which Sid Dresser, chairman of the Metropolitan Section, will serve as chairman.

Afternoons Reserved for Sports

As stated in Chronicle and Comment the technical sessions and conferences have, with one exception, been scheduled for the forenoons, all tournaments and other events being arranged for the afternoons, with the evening sessions devoted mostly to popular subjects which will be of interest to every member at the Summer Meeting.

The General Session on Tuesday evening will be of particular interest to Society members, continuing as it does the subject of Business of Engineering, which was initiated at the Quebec meeting last year. The address at this session will be by Paul G. Hoffman, who has made an enviable reputation in the selling of motor-vehicles. The subject of his paper is What I Think Engineers Are Good For—and How. Members will recognize the chairman of the session as the speaker at the Quebec Business-of-Engineering Session, Norman G. Shidle, who discussed The Engineer as a Business Man. The session will start promptly at 8.30 p. m., the Business Session of the Society being adjourned, if necessary, until the following morning so as to start the General Session on time.

Engine designers will be particularly interested in the Engine Session on Wednesday morning, at which W. A. Whatmough, well-known consulting engineer from England, will explain his theories on combustion-chamber design. As all engineers do not agree with the theories advanced by Mr. Whatmough, the discussion of his paper should provide considerable food for thought. R. N. Janeway and Alex Taub are to present prepared discussions.

Although simultaneous sessions are being scheduled, it will be found that the Meetings Committee has avoided any conflict that will prevent members from attending any session at which they desire to be present.

Informal Conferences Inaugurated

This year the Meetings Committee is inaugurating conferences instead of formal sessions for the discussion of certain subjects. These conferences will be informal, in some cases no minutes being taken. The most important of these conferences will be the one on mixture-distribution, to be held in the Lounge on Thursday morning. Several members have agreed to submit prepared discussion, but a definite limit of 10 min. for presentation has been specified by the Motor-Vehicle Committee to allow time for every viewpoint to be submitted. It is felt that the holding of conferences on controversial questions on which there is insufficient material to warrant a comprehensive paper will be of considerable value and will pave the way to submission of such papers at future meetings.

Body Dinner-Session

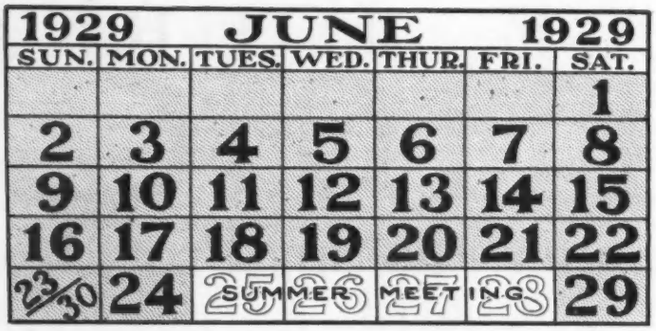
Another innovation in Summer Meeting sessions will be the dinner sponsored by the Detroit Body Division on Wednesday evening. This will be patterned after Detroit body meetings, the dining-room doors being opened at 7:30 and the meeting immediately following the dinner. The speaker for the dinner has not yet been announced by the Detroit Body Division. Presumably, a special announcement giving the detailed program for this event is to be issued.

Members will be greatly interested in the photophone demonstration which will be made at this meeting by Dr. John B. Taylor, of the General Electric Co. In this demonstration Dr. Taylor makes light waves audible and sound waves visible, the demonstration visualizing the mechanism of the movietone developed by the General Electric Co. for the "talkies."

Tournaments as Usual

The usual golf, tennis and archery tournaments will be held during the Summer Meeting, and an innovation this year will be the publication of booklets giving the rules and regulations of the tournaments. The Archery Committee is also issuing *instructions* in the ancient and honorable sport, feeling that archery should

play a more prominent part in S.A.E. meetings and that members should be encouraged to enter the various events. Additional equipment has been purchased by the Meetings Committee so that four targets will be available, which will make simultaneous shooting by 16 contestants possible. L. A. Chaminade and Mrs. Chaminade have been appointed Field Captain and Lady Captain respectively, and a large part of the lawn will be roped off for the archery course.



S.A.E. Golf Trophy

Beginning with the Saranac meeting, the S.A.E. golf champion will be awarded an S.A.E. Golf Trophy. This will be the property of the Society, which will award it to each year's golf champion, who will be its custodian until the following meeting. The Saranac tournament will be based on 54 holes of medal play, the score for the qualifying round on the first day being considered the first round of the tournament. Members will be divided into flights on the basis of their Club handicaps. There will also be a Blind Bogey Tournament. Several other events are to be arranged for by the Golf Committee, of which J. B. Shea is chairman.

Mystery Field Day

When the Field Day is mentioned members will naturally think of the many S.A.E. Field Days that have been held, at which the S.A.E. athletes showed their prowess in the 100-yard dash, the shot-put, the high jump and other events. Under the chairmanship of S. L. Bradley, the Field Day at Saranac will be a distinct departure from history. No skill or strength will be required, merely a sense of humor, as the following list of events indicates:

Crab Race
One Out
Volley-Ball Kicking
Sack Relay
Match-Box Passing
Balloon-and-Bag Race
Prohibition Race
Four-Legged Sack Race
Hidden Kicks
Volstead Race
Centipede Race
Lemon Tossing
Stepping Stones
Marshmallow Eating
Egg-Throwing Contest

Three of these events are for women only, and three others coeducational.

The Saranac Field Day is the development of several similar events run off at Cleveland Section outings, at which the spectators enjoyed the events as much as the contestants, possibly more.

National Meetings

Summer—June 25 to 28
Saranac Inn, Saranac Lake, N. Y.

Western Aeronautic—August
Wichita, Kan.

Cleveland Aeronautic—Aug. 26 to 28
Hollenden Hotel, Cleveland.

Production—Oct. 2 to 4
Hotel Cleveland, Cleveland.

Transportation—November
Philadelphia or Toronto.

Annual Dinner—Jan. 9, 1930
New York City.

Annual—Jan. 21 to 24, 1930
Book-Cadillac Hotel, Detroit.

Scoring in the several events will be recorded not only on an individual basis but on a Section basis so that the Section whose representatives pile up the greatest number of points shall be duly recognized.

The Water Carnival

Under the chairmanship of C. N. Dawe, a Water Carnival is being planned which will be featured by a diving and swimming exhibition in which Betty Pinkston and Pete Desjardins, Olympic diving champions, and Kathryn Brown, Metropolitan diving champion, will take part. The regular events for membership competition will include a 25-yard swim for men and women, a greased-pole tilting contest, a canoe-tilting contest, an inter-Section nightshirt relay race, an obstacle relay race, a worst-dive contest and a canoe race.

Events Social

Owing to the success of the Country Fair at Quebec, the Meetings Committee is sponsoring a Barn Dance in the Casino on Tuesday evening, Fred Cornell being in charge of the plans for this event, and special scenery is to be installed for it. The wearing of appropriate costumes by those who take part will further impart a realistic atmosphere to the dance.

Informal dancing is to follow the Detroit dinner-meeting on Wednesday evening, and the Grand Ball will be held as usual on Thursday evening, when the report of the Nominating Committee will be announced.

The Meetings Committee is scheduling all tournaments for the ladies during the forenoons while the technical meetings are in session, thus giving the ladies the right-of-way during the forenoons on the golf course, tennis courts and the archery course. The usual bridge games are being scheduled and the Field Day, Water Carnival and Sightseeing Trips will keep the ladies occupied, either as contestants or spectators, in the afternoons. The evening sessions will also be of interest to the ladies as well as the men.

Daily SAE

This year the *Daily SAE* is being published by and through the courtesy of the Timken Roller Bearing Co. S.A.E. newsboys will distribute the papers during breakfast each day.

Sightseeing

In view of the many historic points within reach of Saranac, a sightseeing trip is being arranged by Horace A. Brown, Jr., the itinerary for which will include Paul Smiths, Saranac Lake, Lake Placid, John Brown's Grave and Round Mirror Lake, with a stop for tea at Turtle Pond Lodge. Some members undoubtedly will desire to arrange special sightseeing trips to Ausable Chasm and Plattsburg.

Special Notices

Members have received the New York Central timetable giving the schedule for the special trains and cars and the regular trains. Certificates were enclosed with the MEETING BULLETIN mailed on May 25 entitling the members and their families to 1½-fare privileges. Pullman reservations should be made through the Section representatives listed in the TRANSPORTATION BULLETIN.

Members driving to Saranac from New York City or the East should take the road from Lake George to Saranac via Long Lake and Tupper Lake, not through Elizabethtown and Lake Placid. Members driving in from or through Buffalo should take the road through Watertown, Gouverneur and Tupper Lake instead of through Oswego, Watertown, Potsdam and Paul Smiths, the route previously recommended. The roads on the routes now recommended are in excellent condition and are much shorter than those listed in the TRANSPORTATION BULLETIN.

Summer Meeting Technical Program

Saranac Inn — June 25 to 28 — Saranac Lake, N. Y.

Tuesday, June 25

8:30 P.M.—BUSINESS-OF-ENGINEERING SESSION—LOUNGE

(Sponsored by the Meetings Committee)
N. G. Shidle, *Chairman*

What I Think Engineers Are Good For—and How—Paul G. Hoffman, Vice-President, Studebaker Corp. of America

Wednesday, June 26

9:30 A.M.—COMBUSTION SESSION—CASINO

(Sponsored by the Motor-Vehicle Committee)
W. T. Fishleigh, *Chairman*

Combustion-Chamber Design in Theory and Practice—W. A. Whatmough, Consulting Engineer, England

Written Discussion by R. N. Janeway, Consulting Engineer, and Alex Taub, Chevrolet Motor Co.

9:30 A.M.—MOTOR-TRUCK-DESIGN CONFERENCE—CASINO (Pier Level)

(Sponsored by the Transportation Committee)
F. K. Glynn, *Chairman*

Extending the Use of Motor-Vehicles Beyond the Field of Transportation—T. C. Smith, Engineer, American Telephone & Telegraph Co.

Motion Picture: Semi-Trailer and Four-Wheel Trailer Operation—H. W. Raymond, Lapeer Trailer Corp.

130 P.M.—CHASSIS CONFERENCE—CASINO

(Sponsored by the Research Committee)
F. F. Chandler, *Chairman*

Report on Headlighting Research—H. H. Allen, Bureau of Standards

Report on Riding-Quality Research—Dr. Fred A. Moss, George Washington University

Progress Reports from Front-Wheel-Alignment Research Subcommittee—Prof. J. M. Nickelsen, University of Michigan; William B. Barnes, Auburn Automobile Co.

Measurement of Angular Velocities in Automobile Bodies by Means of a Gyroscopic Recorder—Merritt L. Fox, State University of Iowa

7 P.M.—BODY DINNER—DINING ROOM

(Sponsored by the Detroit Body Division)
President W. R. Strickland, *Chairman*
(Speaker to be announced)

Photophone Demonstration by Dr. John B. Taylor, General Electric Co.

Thursday, June 27

9:30 A.M.—TRANSPORTATION SESSION—CASINO

(Sponsored by the Transportation Committee)
H. F. Fritch, *Chairman*

Long-Distance Bus Transportation—R. E. Plimpton, Associate Editor, *Bus Transportation*

The Science of Business Applied to Motor-Truck Operation—Nathaniel Mallouf, President, Mallouf Haulage & Maintenance Co.

9:30 A.M.—MIXTURE-DISTRIBUTION CONFERENCE—LOUNGE

(Sponsored by the Motor-Vehicle Committee)
O. C. Berry, *Chairman*

Discussion by H. W. Best, Sheffield Scientific School; C. S. Kegerreis, Tillotson Mfg. Co.; J. B. Macauley, Chrysler Motors; P. S. Tice, Stewart-Warner Speedometer Corp.; C. L. Petze, Massachusetts Institute of Technology; C. F. Taylor, Massachusetts Institute of Technology; E. S. Marks, H. H. Franklin Mfg. Co.; W. P. Deppé, Deppé Motors Corp.; E. D. Herrick, Lycoming Mfg. Co.; D. P. Barnard, 4th, Standard Oil Co., and Capt. W. C. Thee, Massachusetts Institute of Technology

8:30 P.M.—AIRSHIP SESSION—CASINO

(Sponsored by the Aeronautic Committee)
Edward P. Warner, *Chairman*

Airship Transportation—V. R. Jacobs, Assistant Manager, Aeronautic Department, Goodyear Tire & Rubber Co.

Friday, June 28

9:30 A.M.—RESEARCH SESSION—CASINO

(Sponsored by the Research Committee)
H. L. Horning, *Chairman*

Cooperative Fuel Research from 1922 to 1929—Dr. H. C. Dickinson, Bureau of Standards

Volatility Data on Natural Gasoline and Blended Fuels—Dr. O. C. Bridgeman, Bureau of Standards

Present Status of Equilibrium Volatility Work at the Bureau of Standards—Dr. O. C. Bridgeman, Bureau of Standards

Horsepower Correction for Atmospheric Humidity—Donald Brooks, Bureau of Standards

Program for Design-Factor Engine-Acceleration Tests—Donald Brooks, Bureau of Standards

Waukesha Entertains Milwaukeeans

Rail-Car Ride, Inspection, Dinner and Fuels Feature Meeting at Which H. L. Horning's Company Is Host

MILWAUKEE closed its year's program of Section meetings with a rail-car trip to Waukesha, Wis., where Section members enjoyed an inspection trip through the manufacturing plants and research laboratories of the Waukesha Motor Co., dined, and listened to papers on Distillate Fuels and Motor-Cars. About 70 members and guests boarded the rail-car in Milwaukee, and a dozen more at West Allis. These were joined by local men and some who had arrived by other means of transportation, until 250 took the inspection trip and nearly 300 enjoyed the dinner provided by the host.

All were ushered to the registration desks, where they were given attractive souvenir booklets, and then to a long table where H. L. Horning invited them to refresh themselves with good ginger ale, made in Waukesha. According to H. L. Debbink, who should know, the maidens who served it proved attractive enough to convince some of the repeat customers that there actually was a kick in the beverage. Guides were assigned by J. E. Long to show the guests in groups through various manufacturing, assembling and testing departments.

Going then to the research laboratories, items of interest were pointed out by J. B. Fisher and his assistants. Among them are nine dynamometers, many of them with engines connected for various kinds of research work, including evaluation of the detonation characteristics of fuels, measuring exhaust-gas temperatures, volumetric efficiency and water-pump discharge, blow-by past piston-rings, and airflow through radiator. Stands are provided for checking the power of the engine and its operation at angles up to 40 deg. from the horizontal, as well as in the normal position. Among the unusual testing machines was one for bending stresses and elastic properties of material, made by Carl Schenck, of Darmstadt, Germany, which was demonstrated by R. N. Schafer. We are indebted to the Waukesha Motor Co. for the accompanying photographs of the meeting.

Challenger Picks the Weapons

Following the dinner, Chairman C. L. Cole called the meeting to order, and a resolution offered by Vice-Chairman Arthur Wollensak was passed unanimously, as follows:

Resolved, that the Milwaukee Section challenge the other Sections of the Society of Automotive Engineers to an outboard motorboat race at the Summer Meeting at Lake Saranac, this contest to be known as the Milwaukee Section's stunt. Evinrude motors and Penn Yan boats will be provided by the Milwaukee Section. Each Section shall appoint one pilot who is a member of that Section.

Be it further resolved that this challenge be duly printed in the June issue of the S.A.E. JOURNAL and that our Secretary send a copy of this resolution to the secretaries of the other sections.

After voicing the thanks of the Section to the Waukesha Motor Co. for the splendid entertainment provided, Chairman Cole called upon H. L. Horning, president of the entertaining company, to preside at the technical session.

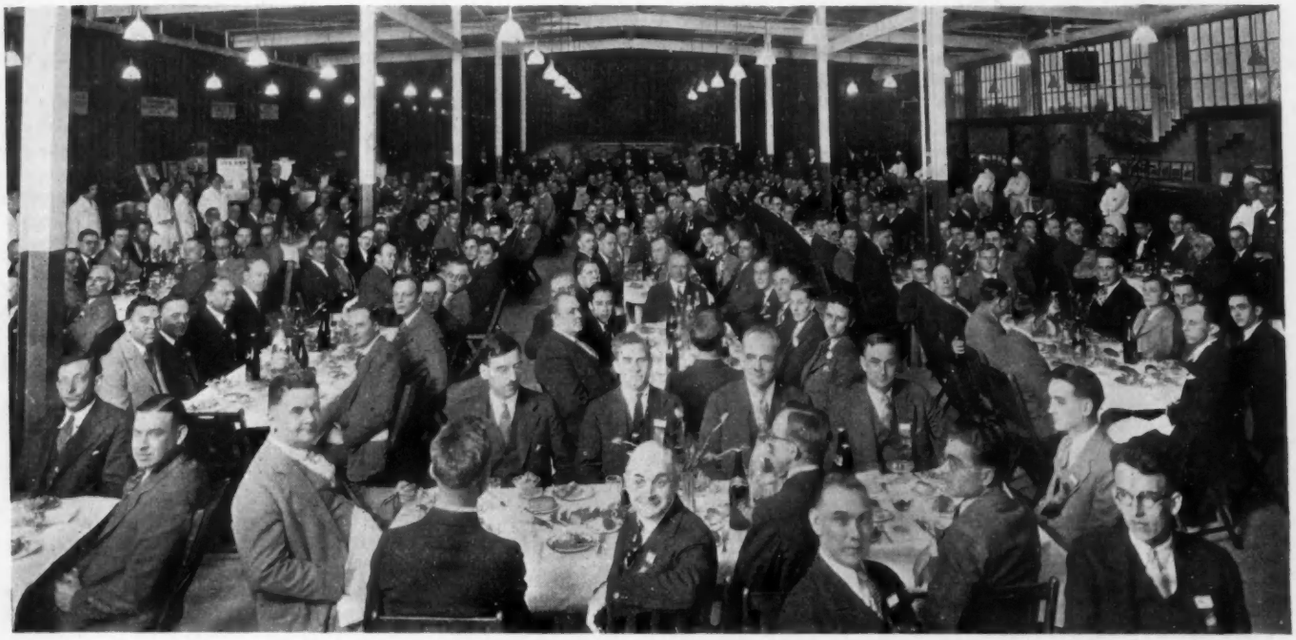
Mr. Horning expressed appreciation for the courtesy of the Chicago & North-Western Railroad Co. and the Whitney Co. for bringing their rail-cars and locomotive for inspection. He also said something of the objects of the Waukesha Motor Co. in building the new engineering department in which the meeting was held.

Fuels for Rail-Car Engines

E. Wanamaker, the first scheduled speaker, discussed the subject of distillate fuels. Since the Chicago, Rock Island & Pacific Railroad, of which he is electrical engineer, penetrates the Seminole oil fields, he has become greatly interested in the use of oil fuel on railroads. He said that liquid fuels are not an actual necessity for any purpose other than for use in internal-combustion engines and ships of war, but lubricants for all kinds of machinery are necessary; therefore the demand for lubricants must be considered in any study of oil as fuel. The following are among the possible liquid fuels for rail-engine operation: gasoline, benzol, kerosene, distillate, light Diesel oils, heavy Diesel oils, and fuel oils.

From this list several items can be eliminated; benzol, because it is generally too expensive; kerosene, because it is little if any cheaper than gasoline; and fuel oil, because it has been

(LEFT) TESTING MACHINE FOR BENDING-STRESSES AND ELASTIC PROPERTIES BEING DEMONSTRATED BY R. N. SCHAFER. (RIGHT) H. L. HORNING POINTING OUT THE PUMP WHICH CIRCULATES COOLING WATER THROUGH THE RADIATOR THAT TOWERS OVER SECTION-CHAIRMAN C. L. COLE.



"Some Are Engineers" to the Number of 300, Being Fed by the Waukesha Motor Co.

used successfully only in large, slow-speed Diesel engines.

Of the fuels remaining, distillate can be burned in a well-designed and well-built gasoline engine having a specially designed carbureter for atomizing and mixing the fuel, provided it has slightly lower compression than usual and minor changes are made in the cylinder-head design. Light Diesel oils can be used in solid-injection Diesel engines having metering pumps delivering fuel at a pressure of 3000 to 10,000 lb. per sq. in., but Mr. Wanamaker regards heavy Diesel oil as suitable for use only with air injection, which is not adapted for railroad use because of the low speeds and great weight involved.

Distillate Is Step-Child of Oil

Distillation divides the crude oil into three lighter fractions: gasoline, naphtha, and kerosene, and two heavier fractions: gas oil and fuel oil. The light fractions are both stable and readily marketable, and the heavy fractions are readily converted into various products, including lubricating oil. Gasoline is also produced from them by the cracking process, leaving distillate bottoms, which is hard to market. All of this material that will boil off at 600 deg. fahr. is classed as distillate, which is suitable fuel for a properly designed engine, being similar to kerosene in properties but free from the knocking tendencies of that fuel.

Mr. Wanamaker said that 9 per cent of the rated capacity of the cracking plants represents the potential supply of distillate. This is being produced constantly but often is diverted to the most convenient outlet, usually being mixed into the steam fuel-oil. As long as gasoline is made by cracking petroleum, distillate will be produced in quantities vastly greater than any possible demand from the railroads, according to the speaker, who gave a list of estimated comparative prices for gasoline and distillate in which refinery prices of 10, 13, 16, and 19 cents for gasoline correspond to 4, 6, 8, and 10 cents for distillate. It is said that distillate can be handled and stored with greater safety and less waste than gasoline.

SECTION REPORTS	Page
Buffalo	666
Chicago	663
Cleveland	572
Detroit	573
Indiana	665
Metropolitan	663
Milwaukee	570
New England	665
Northern California	659, 661
Pennsylvania	657, 665
Pittsburgh	573
Southern California	662
St. Louis	572
Wichita	659

Charles O. Guernsey, of the J. G. Brill Co., the second speaker, talked on the subject of motor rail-cars, which he said are now in daily operation in sizes up to 800 hp. and are growing still larger.

After enumerating the main classes of service to which rail-cars are best adapted and the advantages they possess, Mr. Guernsey said that good maintenance has resulted in an availability of 95 per cent over a period of several years, whereas poorer maintenance has resulted in a far lower percentage of availability in other cars of identical design.

Railroad officials seem prone to select the largest available car for almost any service. Although the range of economical service for a given size of car is not narrow, the greatest economy results from the selection of a suitable size.

Engine conditions are ideal in a rail-car, since the engine is enclosed and protected against cold and dust. With a good oil-filter, satisfactory service has been obtained from lubricating oil in a gasoline engine with changes only once in 4000 miles; but, under less favorable conditions, as in a distillate engine without sufficient manifold heating, the oil should be changed once in 500 miles.

Generator Field Control Systems

For electric generators, which are said to be used on all American rail-cars of more than 200 hp., Mr. Guernsey described the "K" differential control of the generator field as the simplest and least expensive method of control. Another system, involving re-

mote control, is universally applied where heavy currents are used, as in electric locomotives. High voltages are thus kept away from the operator, and the contact conditions are such as to reduce the tendency to burn. Other advantages are that heavy cables do not need to be carried the length of the car for double controls or double powerplants, and the transition can be made from series to parallel connections of the motors without closing the engine throttle. Mention was made of an ideal electric transmission which utilizes a simpler main generator and approximates the ideal loading condition for the engine.

Mr. Guernsey's final suggestion was for a small separate powerplant to drive a battery-charging generator, air-compressor and other auxiliary equipment. This, he said, will provide an emergency source of power for starting the main engine and result in economies in engine operation and transmission and other incidental advantages.

The meeting closed with the teller's announcement of the election of the Section officers who had been nominated, as follows: Chairman, A. C. Wollensak; Vice-Chairman, J. R. Francis; Treasurer, W. F. Krenzke; and Secretary, H. L. Debbink.

Production Meeting at Cleveland

H. S. McClellan Pictures Car-Production Methods as Learned with Chrysler

THE CLEVELAND Section devoted the final meeting of its season to production, hearing and discussing a paper by H. S. McClellan, superintendent of the Highland Park plant of Chrysler Motors. Attendance at the meeting, which followed the usual dinner at the Hotel Cleveland, was 154; and much interest was shown by the discussion and questions, particularly on the subject of wage payments and bonuses.

At the close of the meeting, the election of the following officers was announced: Chairman, W. E. England; Vice-Chairman, Ferdinand Jehle; Treasurer, H. F. Sauer; Secretary, Ben Blair. W. F. Donkin, who made the arrangements for this meeting, was called to the chair by Chairman Ferdinand Jehle to introduce the speaker and lead the discussion.

Modern Production Plan Outlined

After brushing in a background of economic conditions, Mr. McClellan outlined the modern plan under which the administrative heads of the company issue a program to the planning division, on which tentative purchasing schedules for several months in advance are planned. Monthly releases, which provide for a constant flow of material into the plant, are arranged by the scheduling department in coordination with the sales department.

Careful attention to these matters saves handling, storing, and investment, as it is not unusual to turn over inventories of all production materials 25 or 30 times per year. Bulky materials especially should be delivered by some method which will assure a steady supply without the need of an undue amount on hand.

Materials such as forgings, castings and small parts that are delivered in bulk can often be counted and inspected at the point of unloading and delivered directly to the shop floor. Few materials really need to be stored in stockroom bins. Handling economies mentioned by Mr. McClellan included conveyors, chutes from one machine to the next, and trays or steel pans that can be stacked with parts that require particularly careful handling.

Profitable Machine Methods

Machining or processing of parts is a fascinating and never-ending study. Machines should be arranged to enable one man to operate as many machines as possible with little walking or physical effort. Hoists are faster and cheaper than labor, and Mr. McClellan believes that jigs and fixtures should be designed to require less time for cleaning, loading and unloading. Rotating or indexing fixtures which permit loading and unloading while the machine is operating are often found profitable. Mr. McClellan recommends occasional spaces in a long production line where small banks of materials at different stages of completion can be accumulated to be drawn on to maintain production whenever repairs to machinery or tools are necessary.

Special semi-automatic machinery mentioned as profitable in large production includes machines that will turn all six pins of a crankshaft simultaneously, within limits close enough for finishing by a single grinding operation, and multiple machines for drilling and operations of a similar nature. Various grinding methods also are being developed, among them centerless grinding on one machine of several diameters, including the taper at the end of an axle shaft. Hubs and back faces of differential side-gears are being ground simultaneously and accurately by a double-edged grinding-wheel maintained at the correct distance from the cone center of the gear by diamond-tipped gages. The gears are held on a stub arbor with a series of balls between the teeth of the gears. Hydraulic feed is being used more and more for grinding, drilling, and other machines, and super-high-speed steels suggest to Mr. McClellan the possibility that much of our present machinery may soon be obsolete.

Foreman training, particularly in business matters, was emphasized, since each foreman is the manager of a department. The inspection required in a department can be budgeted like supplies. Cycle inspection can frequently be used with economy and good results. With this method, the inspector is stationed at the end of the line and gages only one operation on each piece passing him, following a regular cycle which covers the entire series of operations.

Group bonuses make possible an incentive method of payment without the heavy expense involved in the individual records for piece-work. Individual operations are time-studied, hourly rates are graduated according to the workers' skill, and the group is paid according to its production.

Speaker Answers Questions

Asked if the use of grinding in large production is not on the decrease, Mr. McClellan said that, rather, the use of grinding disks is displacing milling-machines on some jobs. He could give little definite information on the super-high-speed steels but said that his organization has 15 or 20 of them under test. In some places they have shown up splendidly and in others they did not stand up well, but he believes that in time many uses will be found for them. The chief trouble he has found is in holding the material with solder of any kind, but encouraging progress along that line is now being made.

Replying to a question about the size of a group that can well participate in a bonus, Mr. McClellan said that large groups are working very well. One or two plants in Detroit are finding the method successful for assembled units, such as axles or engines, on which 25 or 30 groups cooperate.

In the speaker's practice, rates are cut only after a long period, like a year, during which the earnings have been excessive or after process improvements which are responsible for a saving of labor. It has been found harder to get a night gang up to the required degree of efficiency, but satisfactory results have been achieved in many departments.

St. Louis to Organize Section

A DINNER conference held in the Statler Hotel on May 2 resulted in the decision to undertake the organiza-

tion of a St. Louis Section of the Society. The conference was held at the suggestion of H. P. McDonald; those present including D. P. Cartwright, W. L. Dempsey, George P. Dorris, Maurice Fox, Richard F. Hardin, William Klein, Jr., V. C. Kloepper, W. A. Mankey, C. E. Roebke and C. E. Heywood.

In discussing the possibilities of Section activities, it was reported that of the Society members located in St. Louis about one-fourth are connected with passenger-car companies; one-fourth with parts manufacturers; one-fourth with motor-truck and motor-coach operators, and the others with aircraft manufacturers and oil refiners. It was thought that, with the increased interest in aircraft engineering and the fact that several aircraft manufacturers have recently located in St. Louis, there would be no question as to the success of local activities.

The conference passed a resolution asking the Council of the Society to finance the organization of a St. Louis Section, it being understood that the Organization Committee, consisting of H. P. McDonald, Joseph Conniff, W. L. Dempsey, G. P. Dorris, C. L. Freeman, R. F. Hardin, George F. Heising, V. C. Kloepper and A. O. Payne, would meet several times during the summer to assure a successful series of meetings next season. The first meeting will be an organization meeting, at which temporary officers will be elected, these officers to carry on until the first regular meeting held in the fall, when Section officers will be elected.

Plea for Overalls Men

Joe Graham Talks of Humanities at Close of Detroit Section Season with 400 Present

AN INSPIRATIONAL address by Joseph B. Graham, president of the Graham-Paige Motor Corp., election of officers for next season, the usual good dinner and an entertainment featured the final meeting of the 1928-1929 season of the Detroit Section on May 20 at the Book-Cadillac. "Tuneful melodies, high-stepping blondes, energized atmosphere, palatable grub" is the enticing way in which the *Detroit Super-charger* set forth the attractions of the meeting.

Through the persuasive ability of Society members in the Graham-Paige organization, Mr. Graham was prevailed upon to speak at the meeting somewhat along the lines of his talks to the men of his own company, although it was said to be the first time he had consented to address any other organization than his own. He preferred not to give a formal talk on an assigned topic but to discuss factory organization matters in his own way.

Urges More Steady Employment

Mr. Volstead put the Graham brothers in the motor-truck and later the automobile business, according to the speaker. At the time the Volstead Act was enacted in 1918 the brothers had four bottle factories that were producing 1000 gross beer bottles every 24 hr. The disastrous effect of the new law on this business decided the Grahams to go into some other line and they chose the truck field.

Speaking of the necessity of cooperation in the automotive industry and other industries, Mr. Graham recalled the elucidation of the value of cooperation as made by the president of his old college. "Take two 1's, add them together and you have 2," said his instructor. "Subtract 1 from the other and you have nothing. Divide 1 by the other and the quotient is 1. Multiply 1 by the other and the product is 1. But place two 1's side by side with no sign between them and you have 11."

So it is in life, said Mr. Graham; men stand together, trust one another, work together wholeheartedly on a common task and they have a new power and ability to get results.

Pleading for the men in overalls, the speaker urged that statisticians figure as much on continuity of employment as on production and profits. The human element in factories must be considered, for no matter how good an engineer is, he cannot accomplish the desired results unless there are competent men in overalls on the assembly line. To make men competent for any length of time, they must be happy; and to be contented they must have a steady job.

The sad part about the great automotive industry is the tremendous effort that has to be made over a period of a few months in the year. His hardest job, said Mr. Graham, is to give an order to lay off men because of a decrease in production. He invited study and planning to flatten out the irregular curve on the employment chart in the industry.

Following Mr. Graham's address, the tellers of the vote for Section officers for the season of 1929-1930 announced the results as follows:

Chairman, L. Clayton Hill
Vice-Chairman, P. J. Kent
Treasurer, F. W. Marschner
Secretary, L. K. Snell

The meeting then elected Carl B. Parsons Chairman of the Body Division and appointed Robert Insley Chairman of the Aeronautic Division to fill the vacancy caused by the death of William C. Naylor.

Guests, officers of the Society and officers of the Section seated at the guest table numbered 22, as follows:

C. F. Kettering, vice-president, General Motors Corp.
F. C. Hecox, Cadillac Motor Car Co.
L. K. Snell, consulting engineer
P. J. Kent, Chrysler Corp.; Secretary Detroit Section
Hugh Ferry, treasurer, Packard Motor Car Co.
Harold Neely, vice-president, Graham-Paige Motor Corp.
L. M. Woolson, vice-president, Packard Motor Car Co.
L. Thoms, chief engineer, Graham-Paige Motor Corp.
E. Hopkinson, vice-president, United States Rubber Co.
J. B. Graham, president, Graham-Paige Motor Corp.
B. J. Lemon, United States Rubber Co.; Chairman Detroit Section
L. C. Hill, Murray Corp. of America; Vice-Chairman Detroit Section
W. R. Strickland, chief engineer, Cadillac Motor Car Co.; President S.A.E.
F. W. Marschner, New Departure Mfg. Co.; Treasurer Detroit Section
Frank E. Watts, chief engineer, Hupp Motor Car Corp.
L. D. Tompkins, vice-president, United States Rubber Co.
J. M. Crawford, Chevrolet Motor Co.
William N. Davis, body engineer, Cadillac Motor Car Co.
Robert Insley, Continental Motors Corp.
Carl B. Parsons, president, The Parsons Co.
Buelah Brede, assistant secretary, Detroit Section
John R. Bartholomew, Westinghouse Air Brake Co.

Gain in Meeting Attendance

A statement of attendance at the meetings of the Section during the season just closed shows a gain of 1942 over the last previous season, with a gross attendance of 7454 at the 13 meetings and an average attendance of 573 per meeting. The three largest meetings were the Production Division meeting in conjunction with the National Production Meeting last November, with an attendance of 760; the Body Division meeting in connection with the Annual Meeting of the Society in January, attended by 730, the Aeronautic Division Ladies' Night in February, with 850 present; and the Aeronautic Division Dinner-Meeting in conjunction with the National Aeronautic Meeting last April, with an attendance of 850.

Pittsburgh Organization Planned

PITTSBURGH members of the Society held another meeting on May 23 at Carnegie Institute to discuss organizing a local Section of the Society.

(*Continued on page* 665)

Chronicle and Comment

The Summer Meeting Program

THE committees responsible for the Summer Meeting program arranged for Saranac deserve the congratulations of the Society members for both the excellence of the technical sessions and the interesting social and sports program.

Nine technical sessions and conferences are being held, the Motor Vehicle, Transportation and Research Committees being responsible for two each and the Aeronautic and Meetings Committees and the Detroit Body Division for one session each.

A feature of the entertainment program will be the Water Carnival in which Olympic diving and swimming champions will play a prominent part. The natural advantages of Saranac have made feasible the scheduling of many new entertainment features, but conflict between the technical and social sides of the meeting has been avoided by the Meetings Committee by scheduling all technical sessions during forenoons and evenings, holding the afternoons open for the various tournaments and other events.

Fourth Aeronautic Division Organized

AT the May 10 meeting of the Southern California Section, Commander E. E. Wilson, chief of staff to the Commander of the Aircraft Squadrons, Battle Fleet, was elected Chairman of the Aeronautic Division of the Section, the other Division officers being Donald A. Hall, L. M. Griffith and H. A. Miller, Vice-Chairmen; J. J. Canavan, Treasurer; and G. F. Vultee, Secretary. The complete report of the meeting, at which papers were presented by Lieut.-Commander L. B. Richardson and N. N. Tilley, chief engineer of the Kinner Aircraft & Motor Corp., appears on p. 662 of this issue.

The Aeronautic Division of the Southern California Section is the fourth such Division to be organized by the Sections of the Society, the other three being, in the order named, the Detroit Aeronautic Division, the Metropolitan Aeronautic Division and the Chicago Aeronautic Division.

The Oakland Air Meet

THOSE of us who have never been "over the hump" and still think that we must look to Detroit and New York City for big things in the automotive industry cannot fail to have our eyes opened by the aviation meet conducted by the East Bay members of the Northern California Section on April 20. This was mentioned in the May number of THE JOURNAL and is reported more fully in this issue on p. 659.

Under the leadership of East Bay Vice-Chairman Miller, various committees secured the cooperation of the Oakland airport for the use of the field for the races; an operating company, for the use of a hangar for the dinner and meeting; oil companies, to offer race prizes totalling about $2,000; three motorcoach companies, to furnish transportation for men and goods; and a large number of automotive concerns, to advertise in the program of the meet.

Thus a $6,000 program was furnished to 1000 holders of $2.50 dinner tickets and thousands of spectators without expense or profit to the Section.

What Is an Engineer?

FROM time to time men in the field have endeavored to write a definition of the term "engineer" which would be both comprehensive and explicit.

The Bureau of the Census has asked for a statement of not more than 50 words which will serve as a guide for the census enumerator to decide upon the proper designation of persons who may claim to be engineers. In response to this request a conference was held in the rooms of the American Society of Mechanical Engineers on May 8. Those present agreed upon the following statement:

> The engineer is a man or woman of professional training or experience who applies engineering principles to research, design, construction, operation or production, or who imparts technical instruction in these fields. The professional engineer must be carefully differentiated from the machine or engine operative.

It was further agreed at the meeting that the foregoing definition should be printed in the publications of the various engineering societies with a request for the comments and suggestions of members. It is essential that the final definition be the culmination of ideas from persons in all branches of the engineering profession and it is hoped, therefore, that members of this Society will contribute any ideas they may have for more adequately defining the term.

Holabird Pageant June 12 to 14

THE Society has been notified by the Holabird Quartermaster Depot at Baltimore that the Military Transportation Pageant and Exposition, conducted under the auspices of the Quartermaster Corps, United States Army, is to be held at Camp Holabird, June 12, 13 and 14. The Pageant will be an exposition of transportation equipment used by the different branches of the Military Services. The Society is in no way officially connected with the Pageant but it is believed many members of the Society will feel it will be an exposition of modern motor-vehicle transportation equipment that is worth visiting. For further information refer to p. 654 of this issue of THE JOURNAL.

Wichita Aeronautic Section Proposed

A LUNCHEON conference, attended by 35 members and non-members of the Society, held in Wichita on May 1, resulted in a unanimous decision to undertake the organization of a Wichita Section of the Society. Inasmuch as automotive activities in Wichita are related mainly to aeronautical engineering, the proposed Section would be almost entirely aeronautic.

Air and Ground Transportation Compared

By L. M. Woolson[1]

Cleveland Section Paper — *Illustrated with* Drawings and Charts

BRIEFLY the subject brought up for discussion is intended to direct the thoughts of the members of our Society into channels that I believe claim the interest of practically all with the active participation of but a comparatively few at present. By that I mean that we are all rather extensively involved in ground transportation, but very few of us are actively engaged in air transportation just now. The subject is perhaps timely in that the automobile industry generally is viewing with more than a little interest at present the possibilities in the new field of aircraft, and it is only fitting that the engineers of the industry should give serious thought to the part they may be expected to play in this wonderful drama, the opening scenes of which we are now witnessing and which has aroused such great popular interest.

Comparatively few of the automobile or truck companies have taken such an active and practical interest in aviation as has the company with which I am associated since it has been engaged in aircraft-powerplant development work for the last 14 years. I think it no more than just that I should at this point voice my admiration for the far-sighted vision of the chief executives of our company, past and present, namely Henry B. Joy, Alvan Macauley and J. G. Vincent, who visualized the development of this new industry at such an early date. In this connection it might not be amiss to state that at the time of the Armistice Packard was producing Liberty engines at the rate of more than 50 per day, or 6,000,000 hp. per year, which is approximately four times the present total hydroelectric output of Niagara Falls power stations. Even considering the large-scale production of aircraft engines at present, this war-time record represents several times the most ambitious effort of any individual engine producer now. These statistics are presented not to depreciate the status of the aircraft industry's present rate of production but to lend perhaps a little more color to the picture that lies before us.

Perhaps it would not be amiss for me to paint my picture of the future of aviation. To begin with, aviation has reached its present stage of development without either the benefits in the form of low costs associated with large-scale production as found in the automotive industry or the far more important benefits from an operating standpoint of airport construction on a scale comparable with the enormous strides made in highway construction which have contributed so much to the growth of the automobile industry. That industry has reached its commanding position only by reason of two major contributing factors: (*a*) tens of thousands of miles of good roads have been built on which these automobiles and trucks can operate, and (*b*) enormous demand for automotive products has resulted in mass-production methods and machine-tool equipment that have reduced costs to a point undreamt of in the preceding mechanical age, which in turn has brought about increased demand for automotive products and still further savings. That aviation has been able to advance as far as it has without such aids can be construed perhaps as a dim indication of what the future holds when mass production is under way and universally accessible airports are available.

Comparing the highway-construction and airport situations, we find that for this year the cost of highway construction and maintenance in this Country will

Engineers should give serious thought to the part they may be expected to play in aeronautics.

Aviation has reached its present stage of development without the benefits of low costs associated with large-scale production or airport construction on a scale comparable with the great strides made in highway improvement that have contributed so much to the growth of the automobile industry.

One year's average expenditure of $1,000,000,000 on highways will build not less than 200 first-class completely equipped airports which should be centrally located in the cities.

If the present rate of increase in maintained, 1,500,000 airplanes will be in use in this Country by 1936.

The one cloud on the aviation horizon is the problem of flying under conditions of poor visibility.

Motor-vehicle design engineers are particularly well fitted to effect cost reduction by applying the methods employed in the automobile and motor-truck industries.

Little possibility exists of competition between the airplane and the railroad or motor-truck as a freight carrier; its more extensive use for carrying express matter and valuable goods can reasonably be expected, and the future for its virtually universal adoption for passenger traffic is very bright.

[1] M.S.A.E.—Aeronautical and research engineer, Packard Motor Car Co., Detroit.

amount to no less than $1,000,000,000. The cost of a first-class completely equipped airport worthy of a city of considerable size may be placed at approximately $5,000,000; at least, this is the appropriation that the city of Detroit has made for its new municipal airport. Granting that this figure represents something like an average expenditure, for the price of one year's highway cost we could equip the first 200 cities from the standpoint of population in the United States with such airports and would finish up with the city of Lorain, Ohio, with a population of 37,295. Many of these 200 cities are already equipped with first-class airports and an expenditure of $5,000,000 for many of them would be far more than would be necessary. On the other hand, the cost undoubtedly would run beyond this average figure in many instances due to the high price of real estate in built-up communities.

Another way of visualizing what first-class completely equipped airports would mean in this Country is to state that such airports placed 15 miles apart would reach from the Atlantic to the Pacific and would make transcontinental flying as safe as any conceivable form of transportation, since airplanes would never have to glide more than 7½ miles to reach a field, assuming that an average altitude of 5000 ft. was maintained.

Basing my statement on observations made both abroad and in this Country, I would say that the need for centrally located airports is only just beginning to be appreciated. At present most airports associated with large cities are too far removed from the communities they are intended to serve, and I believe this fact is appreciated in Cleveland, which has one of the finest airports in the world but at a distance represented by ½-hr. ride from the city. Of course, if one is flying from New York City to Cleveland and has to drive ½ hr. to get to the heart of the city, that is a relatively small percentage of the total elapsed time, but when he is flying from Detroit to Cleveland that ½ hr. represents a very considerable percentage of the time. The time in the air from Detroit to Cleveland is 1½ hr., and the time from the airport into the city is ½ hr. or 33 1/3 per cent additional.

I understand that Cleveland has an excellent rapid-transit line direct from the airport which will reduce that time considerably, possibly to 10 min., but I have been much impressed in my travels with the fact that a man traveling by air does not like to break his journey as many times as is now necessary. It is not only a question of the loss in time but also the inconvenience of making a double change in ground transportation.

Factors Influencing Location of Cities

This thought brings us to what is perhaps a somewhat novel conception regarding the future layout of cities. Without pretending to know any more about city planning than the average layman, I have been impressed by certain facts that are perhaps worthy of discussion. Turning back the pages of history, we find that, so far as our Country is concerned, the location of early settlements was determined almost solely by their accessibility to certain points on rivers or lakes which happened to connect with the primitive methods of inland transportation that in those days relied on waterways almost exclusively. For example, Cleveland was first permanently settled in 1796 after having been established as a trading post at the mouth of the Cuyahoga River 10 years earlier. We find that Cleveland's growth was very slow until the opening of the Ohio Canal as far as Akron in 1827, and following this Cleveland became the outlet for the mineral and agricultural products of the State of Ohio. This was some 25 years previous to the advent of railroads in this section of the Country. Chicago is another typical example in that, although it is now the greatest railroad center of the world, it owes its birth and early rapid growth altogether to its favorable location as a lake port coupled with its position at the outlet of the old Illinois and Michigan Canal.

With the coming of the railroad many important cities sprang into existence, many of which were entirely unrelated to any scheme of waterway transportation. Typical examples of such are Omaha and Cheyenne.

Having considered the first two phases of transportation in this Country, namely, waterway and railway, we now come to the third era or that of the highway. Highway construction in our Country lagged seriously for many years primarily because of the network of railroads that met practically all the freight and passenger transportation requirements of our Country during the Nineteenth Century; this, of course, being in marked contrast to early European civilization that followed more or less the old stagecoach routes. With the dawn of the automobile era came the good roads movement and an unparalleled activity in highway construction followed. However, the automobile and motor-truck apparently had no pronounced effect in creating new centers of population. The new arteries seem rather to have brought new life to many communities that were in sad need of rejuvenation due to their sole dependence on the older forms of transportation by railroads or waterways.

Effect That Aviation Will Have

What effect will aviation have on cities of the future? This question, I believe, is not as idle a one as might appear on the surface because successful air transportation will naturally follow the path of least re-

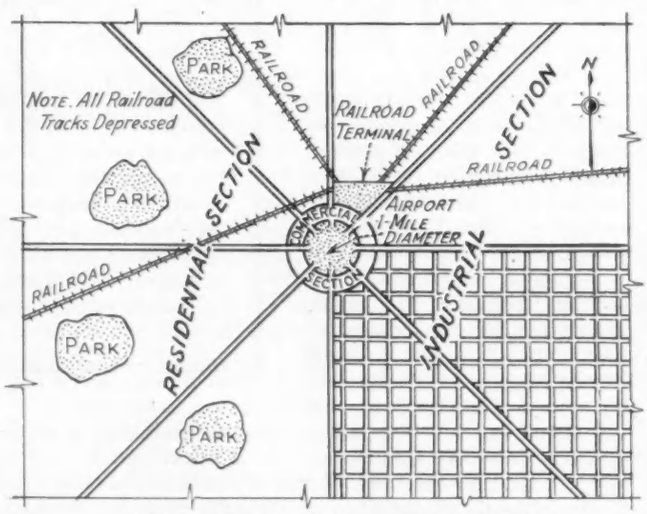


FIG. 1—GENERAL LAYOUT OF AN IDEAL AIR-TRANSPORT CITY

The Business and Industrial Center of Such a City Would Be Grouped about the Airport, and Wide Avenues of Approach Are Provided To Minimize the Danger of Airplanes Flying over Closely Built Territory

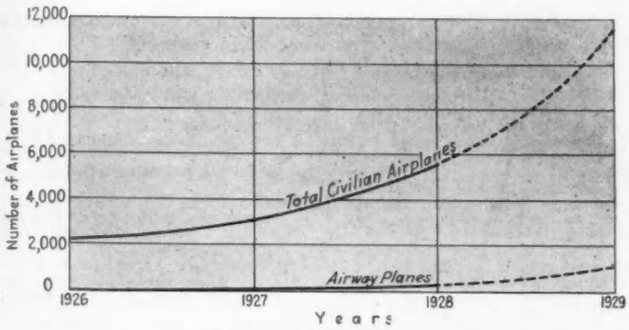


FIG. 2—NUMBER OF CIVILIAN AIRPLANES IN SERVICE

These Figures Were Supplied by the Aeronautics Branch of the Department of Commerce and Indicate That the Number of Airplanes Will Double Each Year

sistance and those communities that are particularly favored by ground and weather conditions for the uninterrupted use of aircraft will be the first to benefit from the new transportation method. Even in the very few years that have passed since commercial aviation began to be looked upon with respect in this Country, many definite indications have come to light of the important influence that aviation will exert on the cities of the future. Wichita, Kan., is an example. A few years ago this town was merely a small trading center for the cattle industry and today it is a prosperous center of aircraft production with six important factories producing perhaps 25 per cent of all the airplanes made in this Country. The conditions that brought this about are those favoring employment of aircraft in commercial service at present, namely, flat territory permitting of landing practically anywhere and good flying weather free from fogs. Furthermore, rail transportation has not been developed in the sparsely settled Western regions, particularly in a north-and-south direction. Another contributing factor is that, due to the widespread locations of the oil fields in that part of the Country, this industry has been able to use air transportation to considerable advantage.

While Wichita is in a class by itself in that its growth has paralleled that of the commercial airplane industry for which it is largely responsible, attention will be focused this year on other cities due to their being the transfer points for the rail-air system to be inaugurated by the Transcontinental Air Transport Co. in cooperation with the Pennsylvania Railroad Co. Columbus, Ohio; Dodge City, Iowa; and Las Vegas, N. M., are the points where passengers change from train to airplane or vice versa, and conceivably each of these cities will receive an important stimulus in growth and may soon become the center of many additional air feeder-lines to tie in with the transcontinental system.

Considering the influence of weather on flying, we find in California, where weather conditions are particularly favorable the year round for the use of aircraft, that the most important advances are being made from the standpoint of the widespread utilization of the airplane for both business and pleasure. On the other hand, every indication shows that air transportation will result in tremendous growth in population and prosperity in those enormous but thinly populated areas west of the Mississippi and east of the Rockies.

Considering the growth of a city around an isolated airport is premature perhaps but I believe numerous instances of such developments, for reasons just as obvious as those bringing about the location of settlements dictated by waterway or railway facilities, will be found. I have ventured to show a general layout of such an ideal city in Fig. 1 with the thought that the more we look ahead and try to visualize the future the more we shall be impressed by the possibilities of aviation. The business and industrial center of such a city would naturally be grouped around the airport in a way comparable to that found in a city like Cleveland, where the business and industrial centers lie within easy access of the railroad and dock terminals. Furthermore, no grade-crossing problem or drawbridge limitations being imposed on the air-transport city of the future, all major activities can be grouped close to the airport. Wide avenues of approach to the airport should be provided from various points of the compass to minimize the danger of airplanes flying over closely built-up territory, and urban needs for transportation will, of course, be provided by subways and automotive surface facilities.

Contrary to popular belief, a journey of several hundred miles is unnecessary to realize the benefits of this vastly speedier method of transportation. Provided

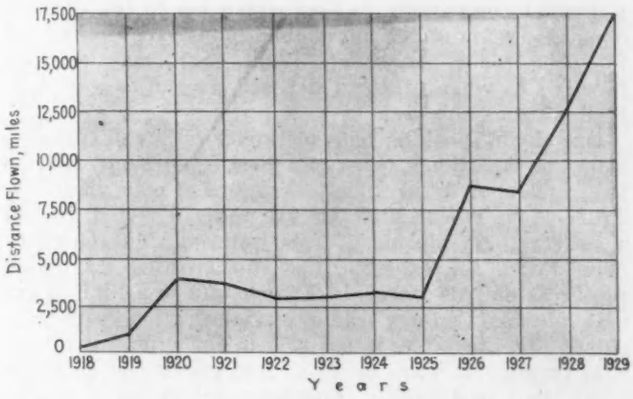


FIG. 3—INCREASE IN THE MILEAGE FLOWN ON AIR-MAIL ROUTES

This Chart Is of Particular Interest Since the Airplane Was First Put to Work for a Living in This Field

one's business at both ends of the trip lies within striking distance of the airport in question, we find that even very short journeys through the air may result in important savings in time. For example, in Cleveland one can fly from the Glenn Martin Field out to the Municipal Airport and back in less time than it would take to make the single journey by any available means of ground transportation. In Detroit we have numerous examples of similar short trips by air. For example, the Municipal Airport is only 1 mile from our factory, and within 30 miles are the Ford Airport, our own flying-field at our proving grounds, and Selfridge Field at Mount Clemens; any of which is only 15 or 20 min. by air from the Municipal Airport, but 1 hr. or more distant by road.

1,500,000 Airplanes by 1936

Fig. 2 relates to the total number of civilian airplanes in service and is based on data supplied by the aeronautics branch of the Department of Commerce. The indications are that we are entering an era of de-

velopment that will approximately double the total number of airplanes in service each succeeding year. In 1936, seven years from now, if such a rate of progress is maintained, 1,500,000 airplanes will be in service in this Country. This seems to be a very extravagant prediction but one that is not entirely removed from the possibilities of the future.

Fig. 3 illustrates the tremendous growth of the air-mail service and is of particular interest since the airplane was first put to work for a living in this field and has done remarkably well. Universal transportation of mail and express matter by air is obviously merely a matter of time, since the added efficiency represented by the tremendous gain in speed of the air mail over any form of surface transportation at very little added expense warrants its adoption wherever possible.

The Problem of Poor Visibility

I have attempted to outline in a very general way the essential facts regarding the present status of air transportation and would lay special stress on the fact that the development has met with considerable success in spite of the fact that comparatively little has been done to encourage the growth of the industry in a manner comparable to that which led to the tremendous expansion of the automobile industry by reason of the good roads movement. What, then, may we look forward to when airports dot our maps the way railroad stations now do?

One cloud, speaking both metaphorically and literally, looms on aviation's otherwise bright horizon; that is the problem of flying under conditions of poor visibility. Tremendous research efforts are being directed toward a satisfactory solution of this problem. The Guggenheim Fund, for example, has concentrated its major resources on this work. In Europe and to a limited extent in this Country radio communication with airplanes has alleviated, if not solved, the problem in that it is possible to warn pilots of bad conditions en route or at their destination. Furthermore, by radio beams any given course can be maintained without reference to ground objects and the effects of drift automatically compensated for, but this method is of no avail in actually bringing the airplane down to the airport under conditions of poor visibility. One can fly from Cleveland to Chicago above the clouds and follow his course regardless of the wind direction, but when he gets over Chicago there is no way that the radio can help him down. Important development work with leader cables has been done in England, and experimentally these cables have been successful to some extent.

So far as our big cities are concerned, this problem of improving visibility undoubtedly will result in focusing more attention on the general smoke nuisance and more rigid enforcement of smoke ordinances may be expected. In addition, the following four factors will tend to improve visibility over a city to a very considerable extent: first, the electrification of all railroads entering the city; second, the more extensive use of suitable oil-burning equipment; third, the more general substitution of central heating and lighting plants in the place of isolated equipment; and last, the increased use of smoke-consuming devices and modern automatic stoking methods.

Now that we have considered the future of aviation from a more or less idealistic standpoint based largely on its normal growth in the last few years, we are ready to consider just how the automobile engineer is particularly well fitted to bring about the very much to be desired reductions in cost by applying similar methods to those so successfully employed in the automobile and motor-truck industry. The point, however, should first be stressed that the design of aircraft is a much more exact science than that of designing automobiles or trucks. This is not only because much lower factors of safety must necessarily be employed and very rigid restrictions are placed on weight, but aerodynamic questions of basic importance must be well understood and the laws of airflow visualized and obeyed as has never been necessary in the designing of automobiles. Stresses throughout the entire structure including the powerplant must be calculated very accurately to conform with the general requirement of maximum strength with minimum weight.

In general, the design of an airplane from the standpoint of performance, balance, maneuverability and visibility brings the automotive engineer into unexplored territory insofar as he is concerned, but even if he should not be directly concerned with such basic questions a clear conception of the requirements is of very material assistance in making even the smallest contribution to the complete airplane. Many technical points or design features are common to passenger automobiles and passenger airplanes on one hand, and freight automobiles or motor-trucks and freight airplanes on the other hand. In every instance the order of importance of the respective qualities is not necessarily the same in regard to ground and air transportation.

Table 1 gives an arbitrary list of those characteristics which can form the basis of comparison of the two types of vehicle viewed from a common standpoint.

TABLE 1—COMPARABLE CHARACTERISTICS OF AUTOMOBILES AND AIRPLANES FOR PASSENGER SERVICE

Automobiles	*Airplanes*
Reliability and Safety	Reliability and Safety
Certainty of functioning of powerplant	Certainty of functioning of powerplant
Freedom from chassis failure	Freedom from structural failures
Freedom from tire trouble	General protection of occupants
Safety	Performance
Efficient brakes and steering	Maximum high-speed limited only by powerplant; low landing-speed
General protection of occupants in case of accident	Excess power for quick take-off and climbing
Comfort	High percentage of useful load
Easy riding	Maximum cabin space
Smoothness or freedom from vibration of engine and transmission	Ease of Control
Quietness or freedom from rattles, squeaks and the like	Good visibility for pilot
Satisfactory interior arrangements with regard to ventilation, light and vision	Minimum effort for flying controls
Performance	Good brake control to assure ease of ground-handling
A satisfactory standard of acceleration, automatically insuring good hill-climbing qualities	Inherent stability of plane
Flexibility or generous torque-range over a large speed-range	Comfort
Maximum speed consistent with highway limitations	Passengers located near center of gravity
Economy	Easy access from ground
In fuel and oil consumption	Efficient lighting and ventilation
Long tire-life	Maximum smoothness or freedom from vibration
Low maintenance expense or freedom from service expense	Minimum disturbance from exhaust and propeller noises
Ease of Control	A resilient landing-gear with good shock-absorbing qualities
Small turning-radius	Economy
Easy steering	Minimum upkeep expense for airplane and engine
Light clutch and brake-pedal pressure	Minimum span or space required for ground storage
	Minimum fuel-consumption with due consideration to performance requirements

In this table six of the more important qualities common to both automobiles and airplanes are listed and the order in which they are arranged in each case signifies in a more or less general way their relative order of importance. So far as automobiles are concerned, reliability and safety can be considered independently since ordinary mechanical failures of powerplant or chassis that do not affect the steering or brakes are not necessarily dangerous, whereas in an airplane practically any structural failure may have serious results and reliability of the powerplant is certainly essential to safety to a far greater extent than in the automobile. Aside from these basic distinctions, the requirements do not differ radically in either case and an engineer well versed in the requirements of automobile design will have an excellent foundation on which to add his studies in this new field.

Considering now the powerplant demands of the automobile and airplane respectively apart from the rest of the structure of these vehicles, I have arranged comparable characteristics in an arbitrary order of importance in Table 2. As in the case of the complete airplane and automobile comparison, we find that we can compare qualities of each type of powerplant on a fairly even basis with the single but very important exception that low specific-weight of an airplane engine is second only in importance to reliability, whereas this qualification can easily be placed last in the order of importance in the case of the automobile engine. This requirement of low specific-weight has, of course, a far-reaching influence in causing the departure of airplane-engine design from that of an automobile engine. Airplane-powerplant requirements vary considerably for different types of service, such as military, extreme high-speed, long distance, and finally, short-haul commercial services. For many years to come apparently no one type of aircraft engine can possibly meet these widely varying requirements, and in the tabulation chief consideration has been given to the type of powerplant required for a privately owned airplane having reasonable cruising and speed ranges.

Flying an Airplane Comparatively Simple

Many people believe that the aviation industry cannot possibly grow as fast as the automobile industry on account of the great skill and long training required of an airplane pilot as compared with demands made on an automobile driver. I am firmly opposed to this viewpoint because I recognize that not only are airplanes being very much improved so that less skill is required to operate them but the tremendous growth of popular interest in aviation resulting so largely from articles found in the daily press and periodicals has given the average layman unconsciously an education that pioneers in the art of flying had to acquire by long and arduous efforts.

TABLE 2—IMPORTANT CHARACTERISTICS OF AUTOMOBILE AND AIRPLANE POWERPLANTS

Automobile	*Airplane*
Reliability	Reliability
Smoothness	Low Specific-Weight
Low Maintenance-Expense	Satisfactory Cooling Characteristics
Flexibility or Flat Torque-Curve Characteristics	Smoothness or Freedom from Vibration
Satisfactory Cooling Characteristics	Low Frontal Area or Adaptability to Fuselage Design
Accessibility	Low Maintenance-Expense
Economy in Fuel and Oil Consumption	Economy in Fuel and Oil Consumption
Long Life	Flexibility or Prompt Response to Throttle
Low Initial-Cost	Long Life
Low Specific-Weight	Low Initial-Cost

Fifty years ago considerable skill was required to ride the old fashioned high-wheeled bicycle and to be able to do this was considered, I believe, no mean athletic accomplishment. Gradual improvement brought the modern safety bicycle on pneumatic tires and the average person could learn to ride in a comparatively short time. Similarly with automobiles, 20 to 25 years ago automobile schools were numerous and well patronized. Tuition consisted of a course in the shop where the mysteries of ignition and carburetion were unfolded and a long course of road instruction accomplished in some cases with the aid of dual control. Nowadays practically everybody drives an automobile and automobile schools are almost a thing of the past. Just how people learn to drive cars in these days is hard to realize; perhaps the latest generation was born with this knowledge. With these examples of the bicycle and automobile eras behind us, can we not look forward with confidence to the not distant future when piloting an airplane will become a matter of 1 hr. or so of instruction instead of the 10 hr. or more that may be considered the minimum at present.

Improvements in airplanes must be brought about to simplify their operation but this development is proceeding very fast. I cite a few such improvements since the war that have already assisted in simplifying their operation. Landing is universally conceded to be the operation requiring the most skill and experience. In this respect improvements have consisted of obtaining better control at lower flying-speeds by more efficient ailerons, elevators and rudder; less tendency to nose over by locating the landing-gear farther forward with respect to the center of gravity of the airplane; far better shock-absorbers preferably consisting of some form of hydraulic control instead of the old-style elastic-cord shock-absorber; improved air foils tending to minimize inadvertent stalling; improved power-loading factors resulting in superior recovery from the stalled position. All of these have resulted in making the landing of an airplane a somewhat more foolproof operation than was the case with military-type machines that were adapted to commercial use at the end of the war.

Another very important point is that today airplanes are built principally of welded steel tubing, a construction that is very much safer in case of a crackup than the old stick-and-wire machines used in 1919 aand thereafter. Nowadays people think nothing of nosing an airplane over in a muddy field, putting it on its back, and flying again a few days later. However, much more remains to be done in this connection and, under the stimulus of the $100,000 prize offered by the Guggenheim Fund for which several famous entries have already been received, we may look for far-reaching results in the next year or so.

The taking-off of an airplane requires somewhat less skill than landing, although perhaps better judgment is required to avoid serious consequences in the event of engine failure at this critical time. Once in the air and at a reasonable altitude, the control of an airplane is a very simple task and wholly comparable to steering a bicycle in that lateral and fore-and-aft trim and directional control are readily managed, assuming reasonably smooth air, with far less mental or physical effort than is required for driving an automobile.

However, much remains to be done in improving the pilot's ability to see directly ahead; practically no airplane can be regarded as ideal in this respect. I am somewhat of a crank on that particular point and cannot see how we can have these 1,500,000 airplanes in the air unless some bright engineer finds a way to enable the pilot to see where he is going, which is not the case with many airplanes today. Furthermore much remains to be done with respect to engine and propeller noise, although many cabin airplanes show marked improvement in this respect. With such drawbacks removed, flying promises to become one of the most fascinating experiences open to mankind.

Air Transportation's Economic Worth

So far I have striven to point out that aviation has reached a stage of development where its future growth is limited, on one hand, only by the need of provision of additional facilities in the form of airports and their equipment, and, on the other hand, by the reduction in cost and improvement in quality associated with the enlargement of manufacturing facilities to correspond to those of our great automobile factories. A very healthy growth is assured by extensions in these two fields, but to give a little thought as to the basic soundness or economic worth of this new form of transportation may be of interest.

So far the novelty and consequently the popular thrill of flying has in a great measure contributed to its rapid growth. A saving in time consequent to the use of this form of transportation has been widely advertised and our wonderful air-mail service gives daily evidence of its efficiency in this regard. However, sooner or later

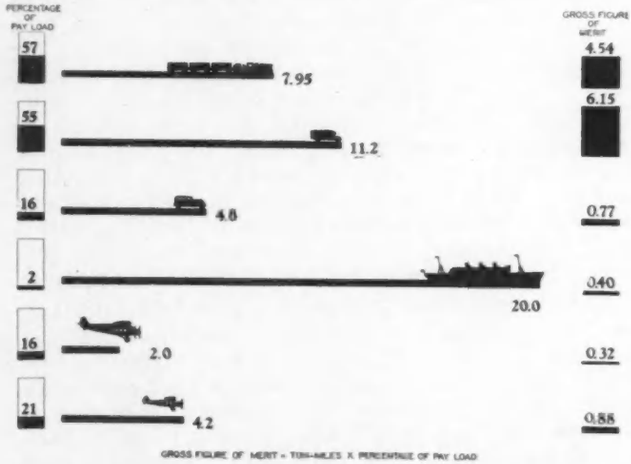


FIG. 4—COMPARISON OF VARIOUS MEANS OF FREIGHT AND PASSENGER TRANSPORTATION ON THE BASIS OF GROSS TON-MILES PER POUND OF FUEL CONSUMED

Points of Interest Are That, While the Steamship Makes the Best Showing Due to a Very Highly Developed Form of Powerplant, It Is Unable To Overcome the Handicap Imposed by the Very Small Percentage of Pay-Load Carried, the Most Efficient Vehicle Being the Motor-Truck Which Carries a High Percentage of Pay-Load and Uses a Highly Refined and Economical Engine

any form of transportation must be judged on the basis of what it does in competition with other available means. Naturally, at this early stage in commercial aviation, the vast amount of statistical information necessary to arrive at any very definite conclusions does not exist in accessible form and this, of course, results from the rapid evolution of the art that does not stand still long enough, so to speak, to obtain the time exposure necessary for a statistical photograph.

If, for example, a comparison of air transport with railroad transport on a logical basis was desired, very extensive reliable data covering items such as capitalization per mile of route, overhead, depreciation, fixed charges of all kinds, operating and maintenance charges and the 1001 items entering into a complete analysis of the two forms of transportation, say on a cost per ton-mile or passenger-mile basis, should be available. Furthermore, much of this bookkeeping statistical data would not be of particular interest to a group of engineers.

I take the liberty of directing attention to a very small part of the complete picture that relates to the efficiency of fuel utilization in several different methods of transportation, namely, railroad passenger and freight services, automobile and motor-truck operations, transatlantic steamship lines, and, finally, two classes of air transport, a high-speed three-engine passenger airplane using gasoline engines and a single-engine cabin airplane using a Diesel engine. In presenting these figures I realize that I am exposing myself to a justifiable criticism since the complete picture may not reflect the indications of those portions that I am showing. My only defense is that the data are undoubtedly reliable so far as statistical information of this sort goes and, although the comparison of fuel efficiency may not be a just one on which to base the all-round efficiency of any particular scheme of transportation, every reason exists for believing that the majority of the fixed charges of these various transportation systems will be more nearly alike than these fuel costs appear to be. If we have succeeded in picking out the largest variable among the many factors that must be considered in making a complete determination of the relative efficiencies, we are at least examining that quality which has the biggest single influence on determining what we might call a figure of merit for each form of transportation.

In compiling this information I wish to make acknowledgment to the New York Central Lines for data used in arriving at railroad fuel costs; to the Cunard and United States Lines for data in regard to the steamship; to a well-known builder of commercial vehicles for data on motor-trucks and motorcoaches; and to the Boeing Air Transport Co. for data regarding the three-engine airplane.

Various Methods of Transportation Compared

Fig. 4 expresses graphically in gross ton-miles per pound of fuel the performance of a typical freight train, motor-truck, passenger automobile, steamship, three-engine airplane and Diesel-engine airplane respectively. I have also listed the ratio of pay-load to total load that constitutes a very important factor in making comparisons between such widely different forms of transport. Taking into consideration this percentage of pay-load and multiplying it by the gross ton-miles per pound of fuel, we obtain the figure of merit given at right which indicates in a general way the efficiency of fuel utilization in each field, disregarding the rather large variations in the British-thermal-unit content of the different fuels employed.

This reveals some rather interesting information

that may be worthy of brief consideration. The motor-truck is the most efficient vehicle shown. This results because it not only carries the highest percentage of pay-load but is using a highly refined and economical engine. The freight train suffers slightly by comparison but it should be realized that the railroads are making tremendous strides in reducing their fuel consumption. For example, the New York Central Lines made a 22-per cent improvement in this regard in the five years elapsing between 1923 and 1928. With more extensive application of the Diesel-electric principle to locomotives and increased electrification activities, the railroad undoubtedly will succeed in closing the gap now existing on this chart.

Third place in this tabulation is taken by the Diesel-engine airplane a considerable distance behind the leaders but with a comfortable margin over its nearest rival, the passenger automobile. This margin would be considerably increased if two other facts were taken into consideration. One is that the specific fuel-cost of the Diesel airplane is roughly one-half that of the automobile, and the other is that the airplane generally reaches its destination by a straight-line flight whereas all forms of surface transportation are handicapped by having to travel at least 25 per cent farther due to the contour of the country and the general amount of detouring necessary to reach the principal cities en route. Although the steamship employs a very highly developed form of powerplant and makes the best showing in terms of gross ton-miles per pound of fuel, it is unable to overcome the tremendous handicap imposed by the very small percentage of pay-load carried.

The next chart, Fig. 5, gives somewhat similar information in terms of passenger-miles per pound of fuel. This comparison is somewhat more favorable to the railroad, which has the best showing followed closely by the Diesel-engine airplane. The motorcoach comes third in this tabulation due largely to its reduced pay-load capacity. The airplane using three gasoline engines suffers from the relatively high cost of fuel as well as the excess power that is considered essential to safety in the present stage of aircraft development.

Summing up, it would appear from these charts that, insofar as the carrying of freight is concerned, little possibility exists of the airplane ever competing with either the railroad or the motor-truck. Where the element of time enters, as in express service or the shipment of valuable merchandise such as silk or perishable out-of-season fruit or vegetables, we may reasonably expect that more extensive use of air transport will be warranted in many cases by the speedy service rendered. Considerations of passenger traffic, however, indicate a very bright future for the practically universal adoption of air transport since on economic grounds it compares very favorably with any form of surface transport and the tremendous saving in time will represent an overwhelming advantage that can-

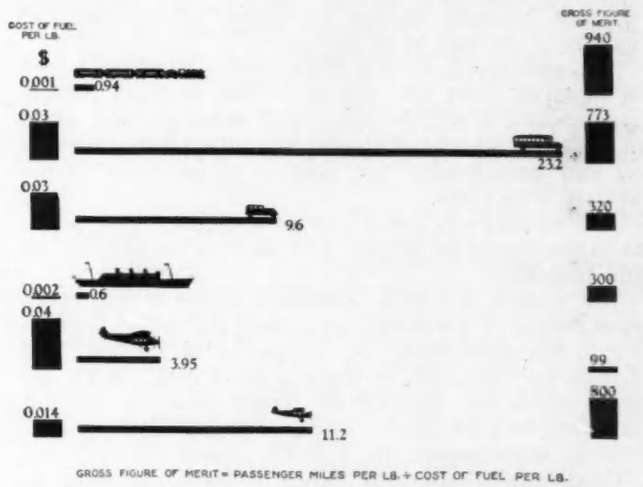


FIG. 5—ANOTHER COMPARISON OF TRANSPORTATION MEANS, IN TERMS OF PASSENGER-MILES PER POUND OF FUEL

The Railroad, Which on the Ton-Mile Basis of Fig 4 Ranked Second, Now Makes the Best Showing and Is Closely Followed by the Single-Diesel-Engine Airplane. While the Motorcoach Makes the Best Showing, If Fuel Consumption Alone Is Considered, Its Reduced Pay-Load Capacity Relegates It to Third Place

not be met by any conceivable improvement in existing forms of surface transport over reasonably long distances. In conclusion, I wish to admit frankly that these last two charts are submitted with reservations as to the deductions to be drawn therefrom and I will sincerely appreciate criticism from those better qualified than I am to make such statistical comparisons.

THE DISCUSSION

CAPT. H. C. RICHARDSON[2], U. S. N.:—How would the ship statistics be altered if the automobile had to carry fuel to take it 3000 miles? I do not believe the pay-load would be a very high percentage. I should also like to know if the statistics on the Diesel engine are based on actual long-distance performance.

L. M. WOOLSON:—I cannot give all the data offhand, but Captain Richardson is right in bringing that point up. The Mauretania, with a tonnage of 30,830 tons, carries 7000 tons of fuel oil, or 23 per cent in fuel for a 3000-mile trip, and I think that is a very good point to emphasize.

The figures on the Diesel-engine airplane are the averages of a large number of tests we have made with fuel aboard for about a 20-hr. flight.

A MEMBER:—I doubt if the speculative advantages of the Diesel engine are well illustrated in the case of the airplane. The comparison should be of the Diesel-engine airplane with the motorcoach and the motor-truck similarly equipped and with the steam engine and the steamship.

MR. WOOLSON:—That is another point which is well taken, but I am dealing with the situation as it exists today. I know of at least one Diesel-engine airplane, but not of any Diesel-engine motorcoaches at present.

EDWARD WALLACE[3]:—Has Mr. Woolson any figures on lighter-than-air Zeppelins propelled by gasoline engines and Diesel engines?

MR. WOOLSON:—I did not include that information

[2] Bureau of Aeronautics, Navy Department, City of Washington.
[3] M.S.A.E.—Staff engineer, Great Lakes Aircraft Corp., Cleveland.

in the list because Carl Fritsche has written a very good paper on that same subject.

A MEMBER:—With a given cooling range with his Diesel-equipped airplane, considering the weight of fuel plus the weight of the engine, can Mr. Woolson get lower specific-weight for the same cruising range?

MR. WOOLSON:—The curves cross between 4 and 5 hr. The Diesel-engine airplane will never be able to compete with a gasoline-engine airplane with fuel for only 2 hr. aboard, from the standpoint of over-all weight combined with the weight of the powerplant and fuel, but from about 4½ hr. and upward the Diesel-engine airplane becomes lighter by reason of the reduced weight of the fuel to be carried.

The assumption on this Diesel-engine airplane, which is based on many test flights, is that with six passengers aboard it will fly about 19.5 miles per gal. at 90 m.p.h. at a fuel cost of ½ cent per mile if using furnace oil and considerably less cost if using some of the heavier Diesel oils.

A MEMBER:—Is there any governmental restriction as to the size of an airport, and what is the safe length and breadth?

MR. WOOLSON:—If I remember correctly the minimum length of a runway for a class A1 rating, according to the Department of Commerce, is 2500 ft., but that is far too small to make a good field. Much depends upon the approaches. There must be no tall buildings or high-tension wires or trees. That is, perhaps, of more importance than the size of the field.

CHAIRMAN FERDINAND JEHLE[4]:—Were the data in the last chart based on the British-thermal-unit cost or the pound-of-fuel cost?

MR. WOOLSON:—Simply the pound-of-fuel cost. In that you can neglect the British-thermal-unit content because you are getting so many British thermal units for your money.

Maintenance Cost a Matter of Design

WESLEY L. SMITH[5]:—Have you any upkeep and maintenance cost figures on Diesel engines? We who are in the transport business find that the fuel cost is about 5 per cent of our total cost, whereas maintenance and upkeep is about 20 per cent.

MR. WOOLSON:—I realize fully that in presenting the fuel cost I am giving a very small proportion of the whole picture. Maintenance expense is purely a matter of the stage of development of the engine. The Wright Whirlwind maintenance expense now is probably 10 per cent of what it was at first. The whole thing goes back to design; I mean proper proportions, bearing surfaces and so forth. Whether it is a steam or a gasoline or an oil engine does not make any difference; if it is properly designed and the "bugs" are all worked out of it, the maintenance should not be excessive.

MR. SMITH:—To give you an idea on that from our actual operations, let me say that the Liberty engines are about 200 per cent better than any other engine that has since been built. We have mechanical forced-landings with Liberty engines about once in every 200,000 miles, and with every other engine you will have a mechanical forced-landing about once in every 30,000 miles; so, if engineering development means anything, we are going backward in aviation.

MR. WOOLSON:—The reason is that some 25,000 Liberty engines were built and the best brains of the Country were worked under a forced draft in getting the faults out of the engine. Even the first Liberty engines gave plenty of grief, as we all know, but now a Liberty engine is a very fine piece of mechanism. The longer any airplane part is in production, the more nearly perfect it will be, if the designers try to make the engine better from the standpoint of operation and not from the standpoint of trying to get more out of the engine. In the Liberty-engine development that work was divided into two distant classes: the research engineer to get more power out of the engine and the improvement engineer for reliability. We never sacrificed strength, so far as I know, anywhere in the Liberty engine to get more output.

W. A. MAYNARD[6]:—Will the characteristics of the Diesel engine have any effect on the relative importance of performance, reliability, safety, comfort, economy and ease of control?

MR. WOOLSON:—Fuel economy will come to the forefront but I did not want to appear prejudiced by putting that any higher up on the list at present than it deserves to be. When we can reduce fuel-consumption cost something like 70 to 80 per cent, as we know we can, that will be a very good talking point. Of course, fuel economy is not so important, as Mr. Smith very rightly points out, but it is surprising how many people will get together and brag about how many miles their cars will go to a gallon.

Reduction of Fire Hazard Most Important

M. R. WELLS[7]:—Has the fire hazard of the Diesel engine as compared with the gasoline engine been considered?

MR. WOOLSON:—We have found it impossible to have a fire with a Diesel engine. I have never had any fuel-line breakage in the air, but on the ground we have broken lines on numerous occasions and scattered the fuel all over the engine and nothing ever happened. I omitted that because I did not want to press that point unduly, but this question of fire hazard is the one reaction we get that stands head and shoulders above all others. Anybody flying a gasoline-engine airplane does not worry much about fire ordinarily. In case of a crackup or even a minor accident on a soft field where you go over on your back and cannot get out of the airplane without assistance, this dread of fire is very, very serious. Many good men have been burned to death just that way. They have not been injured but the airplane has turned upside down, the gasoline has spilled on the engine and caused a fire, and, of course, they are beyond human help when that happens.

Acceleration at the Take-Off

A MEMBER:—How does the Diesel-type engine compare with the gasoline type on acceleration as far as take-off is concerned?

MR. WOOLSON:—A Diesel engine's output is usually rated on a certain maximum fuel-consumption and, especially in the high-speed type, the fuel cannot combine economically with all of the air that the engine takes in. You do not get the intimate mixture of the

[4] M.S.A.E.—Research engineer, White Motor Co., Cleveland.

[5] A.S.A.E.—Superintendent of the eastern division, National Air Transport, Inc., Chicago.

[6] A.S.A.E.—Transportation engineer, White Motor Co., Cleveland.

[7] M.S.A.E.—In charge of engineering department, Trundle Engineering Co., Cleveland.

fuel with the air that you do in the gasoline engine where you have all the time that elapses between the instant the gasoline leaves the jet and joins the air-stream in the carbureter, to the time it passes through the manifold or through the rotary distributor, if your engine has one, and it goes into the cylinder on the suction stroke and gets mixed further on the compression stroke. By the time the spark occurs that mixture is pretty well mixed. You could not hope to do as well as that in a Diesel or any fuel-injection engine where the fuel is injected at a very, very brief interval of time before it is ignited. You cannot get that intimate mixture, naturally, although you can go a long way toward approaching it.

In a gasoline engine you can economically get 130 lb. brake mean effective pressure which corresponds to a fuel consumption of about 0.55 lb. per b.hp-hr. in an air-cooled engine. In a regular stationary Diesel the rating is generally based on a maximum consumption of 0.42 lb. per b.hp-hr. That will give you a good clean exhaust and the engine can run indefinitely at that low rate. If you increase the fuel consumption you inject more fuel, some unburned fuel will go out of the exhaust and a slight smoke will result, but you will get considerably more power; and for take-off and climb we find it convenient to take all we can get out of the engine, and for the same specific fuel-consumption as with the gasoline engine, 0.55 lb. we will say, you can get about 25 per cent more power out of your Diesel. In other words, we can get 120 lb. brake mean effective pressure out of the Diesel for take-off and climb, which compares very favorably with the gasoline engine, although the normal rating of that engine will be based on a brake mean effective pressure of about 110 lb. per sq. in., corresponding to a considerably lower fuel-consumption. When the Department of Commerce has to rate these engines, the problem will be a knotty one because a Diesel will require two rates: one a normal rating and the other an overload rating.

A. H. GODFREY[8]:—What happens in case of water getting into oil as I understand sometimes occurs in oil-burning engines on sea-going vessels?

MR. WOOLSON:—When water gets into the fuel of a gasoline engine the engine generally stops, because the main jet is the only place for the water to come out, but on the Diesel engine we have an advantage in that each cylinder has its own fuel-pump. If the pumps all got water in the fuel simultaneously the engine would have to stop, but, assuming that you are referring to small quantities of water, the inference is that the engine would miss on a few cylinders until the water was eliminated from the system; you are far better off when each cylinder is fed from a different source as it is in a Diesel than you would be with a gasoline engine, many of which rely on a single carbureter.

[8] Tool engineer, Carboloy Co., Inc., Detroit.

Structural Failures in Engines

MR. SMITH:—We are operating some three-engine airplanes and have not had any forced landings yet with them. We think that we have three times as much trouble with three-engine airplanes as with single engine planes, but our troubles are not caused by the carbureter or the ignition. They are caused by structural failures in the engine itself, and I should like to know whether the Diesel eliminates all that. I cannot see wherein the Diesel is any better than any other engine in that respect. We have learned to take care of the ignition and the carbureter and have never had any forced landings from those causes.

MR. WOOLSON:—If the crankshaft is going to break in one engine, it may break in all three, but it should be designed and built so it never will fail. No structural failures should occur in the engine, and if the part is so weak or so near the fatigue limit that it is going to fail, it is entirely possible that two of the engines might go bad from the same cause and within a few hours of each other.

I remember a certain boat race not many years ago when we had one magneto go bad from a certain cause on one lap and on the next lap the other magneto went bad from the same cause, and I think I can recall several cases of a similar nature. The valve gear must not break and the crankshafts must not break; that is all a matter of testing on the ground with heavy overloads for long periods to search out the weaknesses.

A MEMBER:—It seems to me that a speed of 2000 r.p.m. for which the engine is designed would be a little high with respect to the propeller.

MR. WOOLSON:—That is just about the same as the speed of the engines with which we hope to compete. It is high for propeller efficiency, but on the other hand Lindbergh crossed the Atlantic with a direct-drive engine; and, although geared engines are more efficient, the fact remains that very fine performances can be obtained with fairly high-speed engines, especially if the forward speed of the airplane also is high. That must be taken into consideration.

Labor and the Machine

LABOR in this Country knows perfectly well that the introduction of a new machine means more business for the employer and more work for the laborers at higher pay. The average opinions of the other nations are a generation behind us in this matter. But they are awakening, and the time is coming very soon when rationalization and the adoption of American methods will become general.

Certainly we should pay wages commensurate with our standard of living and continue to use our genius to improve our processes. It is our competitive ability to produce at a lower cost and to sell better or lower-priced goods that will get us business.—A. C. Morrison.

The Effect of Gum in Gasoline

By V. VOORHEES[1] AND JOHN O. EISINGER[2]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS, CHARTS AND DRAWINGS

THIS PAPER is divided in two parts. The first part is devoted to engine tests made on gasolines having different gum contents. The tests made indicate the quantity of gum that can be tolerated in a motor fuel before it will noticeably affect engine operation. It was found that only the actually dissolved or preformed gum in a gasoline at the time of use directly affects engine operation. The gum usually collects on the hot parts of the intake system, particularly the inlet valve. Photographs showing the condition of the inlet valve and cylinder-head of the test engine are reproduced. Also, in the first part, the gum-forming tendency of fuels that are stored for some time prior to use is discussed.

The second part of the paper, consisting of the appendix, takes up the causes and methods of testing gasoline for gum. It is shown that gum is chiefly a result of oxidation, which is apparently of the autocatalytic type; and furthermore that, once a gasoline has started to form gum, it usually continues as long as air or oxygen is present.

Since no existing gum tests were found that were satisfactory, a thorough study of methods was undertaken with the object of obtaining a reliable test for gum. Two gum tests were devised, one being an oxidation test designed to show the stability of a gasoline toward gum formation, particularly when stored, and the other a modified steam-evaporation test to show actual gum in solution at the time the test is made.

UNTIL quite recently, with the continual increase in the compression ratio of the automobile engine and the renewed interest in vapor-phase cracking to make antiknock gasoline, refiners have not had to pay much attention to gasoline gumming, because straight-run distillates and distillates from most liquid-phase cracking processes are easily refined to substantially gum-free stable gasolines. In fact, the difficulty of refining vapor-phase fuels was a considerable factor in bringing about the present ascendency of liquid-phase cracking, in spite of the better antiknock properties of the vapor-phase fuels. There are some references to the harmful effects of gum in gasoline-engine fuels, but the writers have been unable to locate any published report of experimental work which shows these effects quantitatively so as to make it possible to define the permissible gum-content. In this paper the effect of gum gasoline on engine performance will be taken up first, and, in the Appendix, the cause of and tests for gum formation in gasoline will be discussed.

How Gum Affects Engine Operation

That gum in gasolines may cause serious trouble when used in an engine is generally recognized. Hall[3] stated in a paper presented before the Institute of Petroleum Technologists in 1915: "A spirit with such (gumming) tendency will eventually clog and stick up the valves of any engine in which it may be used."

About 1925 considerable trouble from sticking of valves was experienced when several cars were run on a vapor-phase gasoline that had been in storage about seven years. No one suspected that this gasoline was appreciably different from any other, as it showed no precipitate although it had that strong varnish-like odor commonly noted in gum-containing fuels. After using about 10 gal. in a Winton car, which at the time had been driven more than 80,000 miles and in which the original valves and guides were rather loose, it was very difficult to remove the valves, as some of the gummy deposit had run down the valve-stems. The deposit on the under side of the inlet-valve head was about 1/16 in. thick and extremely sticky. On a rather new Mercer car, which was using this same fuel, a crowbar was resorted to in the attempt to remove the inlet valves; and, in one or two cases the valve-stem guide came out with the valves. After several similar experiences by other car owners, a copper-dish test was made which showed about 1000 mg. of gum per 100 cc. of gasoline. T. A. Boyd, in a paper[4] presented before the Society of Automotive Engineers, refers to the "brown varnish-like resin" which separates from gasolines of high gum-content and deposits on the fuel and intake systems of automobiles.

Gasoline gum is a resinous, non-volatile product formed by the oxidation and polymerization of certain hydrocarbons. It usually is soluble in the gasoline, but if any is present it is always left behind on evaporation of the gasoline, either as a soft sticky mass, if the temperature of evaporation is low, or a hard, baked deposit if the temperature is somewhat elevated. While some of it may separate out as a flocculent precipitate during long standing, most of it generally stays in solution. Contrary to popular belief, gasolines may be yellow without containing any gum, or may be colorless and yet contain large quantities of gum. Different kinds of gasoline differ considerably in the time required to form gum under a given set of conditions.

For convenience, the gum content of fuels has been divided in two categories. The first is the "potential" gum-forming tendency of a fuel as measured either by the copper-dish test[5] or the oxygen gum-test described in the Appendix. Both of these tests subject the gasoline to oxidizing conditions and indicate the amount of

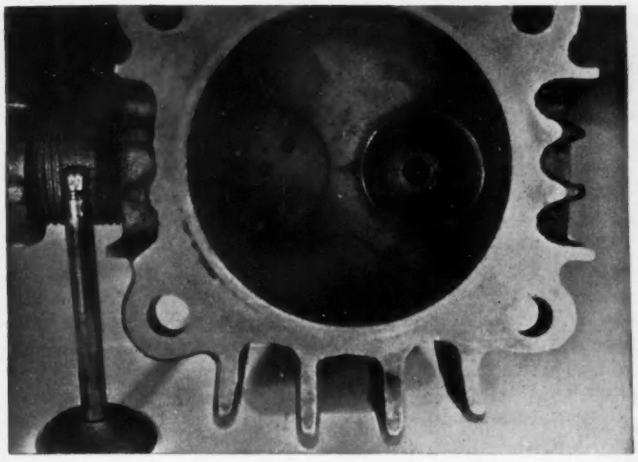
[1] Research chemist, research laboratories, Standard Oil Co. of Indiana, Whiting, Ind.

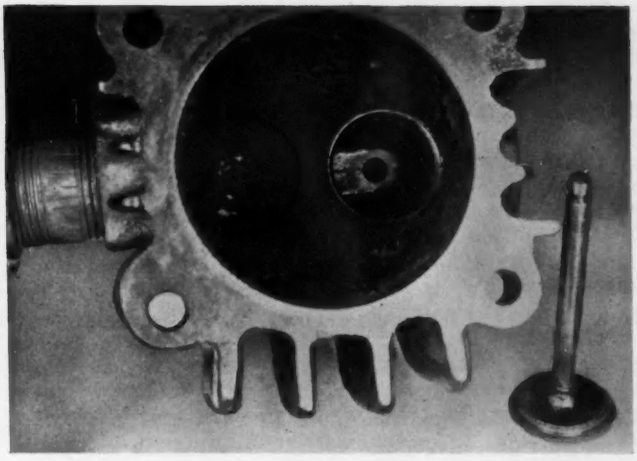
[2] M.S.A.E.—Research engineer, research laboratories, Standard Oil Co. of Indiana, Whiting, Ind.

[3] See *Journal of the Institute of Petroleum Technologists*, 1915, p. 147.

[4] See THE JOURNAL, June, 1926, p. 643; also TRANSACTIONS, vol. 20, p. 103.

[5] Federal Specifications, Method No. 530.1.





RESULTS OF ENGINE TESTS ON TWO GASOLINES HAVING A TENDENCY TO FORM CONSIDERABLE GUM

Fig. 1—Test Run on Fuel No. 11, Which Showed a Potential-Gum Content of 712 Mg. per 100 Cc. by the Copper-Dish Test and 8 Mg. per 100 Cc. by the Modified Steam-Oven Test. No Deposit Was Formed in the Inlet Passage or on the Inlet Valve

Fig. 2—Test Run on Fuel No. 5, Which Contained More Preformed or Actual Gum in Solution, Showing 17 Mg. per 100 Cc. by the Steam-Oven Test and a Potential-Gum Content of 237 Mg. per 100 Cc. by the Copper-Dish Test. An Appreciable Deposit of Gum Was Formed in the Engine

gum that may form in the fuel if stored for a very long time. These tests make no distinction between the gum already formed and present in solution at the time the test is started and that formed during the test. Therefore, we have another category, the "actual" or "preformed" gum which is already in solution at any given time. To determine this preformed gum, a modification of Cooke's steam-oven test[6] is used, which consists principally of evaporating a sample of fuel under non-oxidizing conditions, so that only the gum which has previously been formed in the sample is determined. This test is described in more detail in the Appendix.

Engine Test Procedure

The following engine tests were undertaken to determine the extent to which a fuel should be free of gum so as to avoid repetitions of the experiences cited. This determination requires, first, the ascertaining of whether the potential gum or the preformed gum in a gasoline causes trouble in an engine, and second, how large the gum content may be before engine operation is affected.

For the major part of this investigation, a single-cylinder air-cooled Delco model-850 engine was employed. Loading of the engine was obtained by the generator as regularly furnished, and the engine was operated usually at about 1250 r.p.m., the output of the generator being about 0.8 hp. in most cases. Before each test the engine was cleaned to make sure there was no carbon in the combustion-chamber and no deposit in the inlet passage, and the valves were ground-in. The engine was then run until 5 gal. of the gasoline being tested had been consumed. It was found that this quantity was sufficient to give an indication of gumming with gasolines of moderate gum-content.

After a test, the cylinder-head and the inlet valve were removed and photographed. As the condition of the piston-head was substantially the same after every test regardless of the fuel used, the piston-head was not photographed and the carbon found on it was not collected. The carbon was, however, scraped from the cylinder-head and weighed. The deposit on the under side of the inlet-valve head and in the inlet passage, when present, was removed and weighed, and was taken as a criterion of the gumming tendency of the gasoline tested. This deposit was usually baked on and rather hard, instead of having the sticky, gummy consistency previously mentioned. However, in some cases referred to later, the deposit was of the gummy type.

Typical results from numerous tests made on various kinds of gasoline are given in Table 1. Inspection of these results brings out very clearly the important fact that a gasoline may have a tendency to form considerable gum as shown by the copper-dish test or the oxygen gum-test and yet give satisfactory performance in the engine. This is most strikingly illustrated by test No. 11 which was made on a freshly distilled vapor-phase gasoline. This fuel, which showed a potential-gum content of 712 mg. per 100 cc. by the copper-dish test but only 8 mg. of gum already formed as

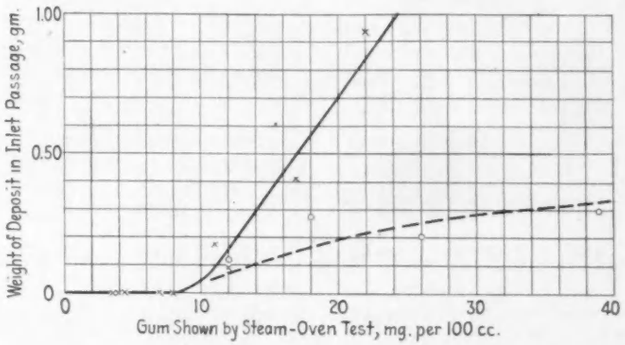


FIG. 3—GUM DEPOSIT IN INLET PASSAGE PLOTTED AGAINST PREFORMED-GUM CONTENT OF FUELS AS DETERMINED BY STEAM-OVEN TEST

The Solid-Line Curve Represents Gasolines in Which Gum Had Been Formed During Storage of the Fuels. The Broken-Line Curve Represents Gum-Stable Gasolines to Which Gum Had Been Added. An Evident Relation Exists Between Actual, or Preformed, Gum and the Deposit in the Engine Inlet-Passage

[6] See Bureau of Mines Report, Serial No. 2686, May, 1925.

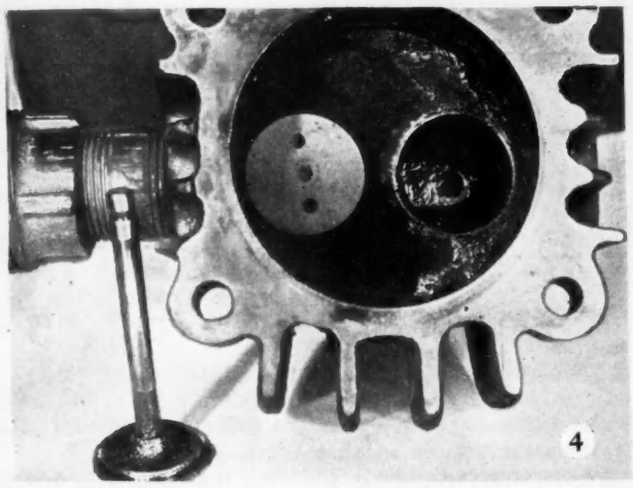
shown by the modified steam-oven test, gave good performance in the engine, with absolutely no deposit in the inlet passage or on the inlet valve, as shown by Fig. 1. On the other hand, fuel No. 5, which contained a somewhat larger amount of performed or actual gum in solution, giving a steam-oven test of 17 mg. per 100 cc., gave an appreciable deposit of gum in the engine, as shown in Table 1 and Fig. 2. Explanation of these results probably lies in the fact that the gasoline is not in the manifold sufficiently long for any considerable amount of oxidation and gum formation to occur, and only gum which has previously been formed in storage can be deposited on the hot surfaces.

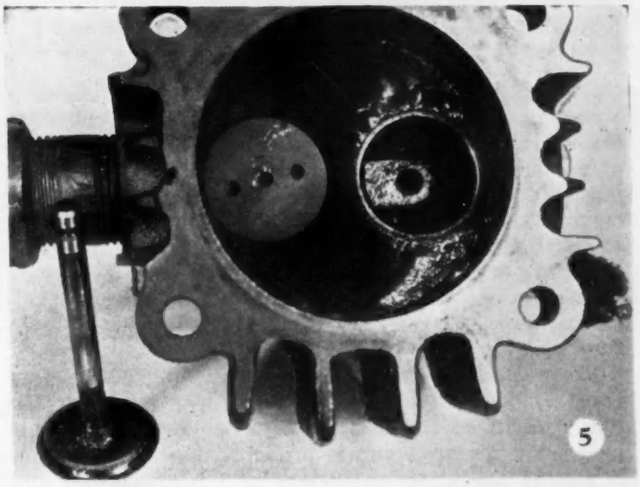
For tests made under approximately the same conditions, the amount of the deposit in the inlet passage has been plotted against the preformed-gum content of the fuels as determined by the steam-oven test, and are shown in Fig. 3. An evident relation exists between actual or preformed gum and the deposit in the inlet passage. In the case of those gasolines to which soluble gum of somewhat different character had been added, the tendency seemed to be for the gum to run into the cylinder, so that the amount left adhering to the valve and inlet passage was low, as revealed by Figs. 4 and 5. The actual percentage of the preformed gum that collected on the intake system, under the conditions of these tests, varied from about 8 to 22 per cent of the total preformed gum in the fuel, for those fuels which contained normal gum. The results of the steam-oven test may ordinarily be used to predict the amount of deposit which will form and the trouble that will ultimately result if the test is made at the same time the gasoline is used. The relation seems to be surprisingly close when it is considered that no means were available to control accurately the engine-operating conditions.

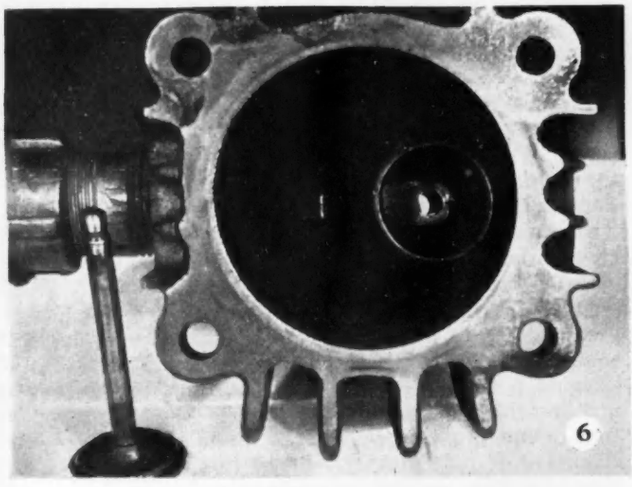
The results of a test made under no-load conditions and at a somewhat lower engine-speed indicate that the temperature of the inlet passage may have some effect on the actual amount as well as the character of the deposit that will form. Run No. 12, made under these conditions, with an inlet-manifold-wall temperature of 135 deg. fahr., gave only a small trace of gummy deposit, as shown by Fig. 8. Run No. 13, on the same fuel, at a higher load and an intake-manifold-wall temperature of 175 deg. fahr., showed a much greater deposit (see Fig. 9) which was decidedly hard and brittle. All of the other tests reported were made at the higher manifold-temperature.

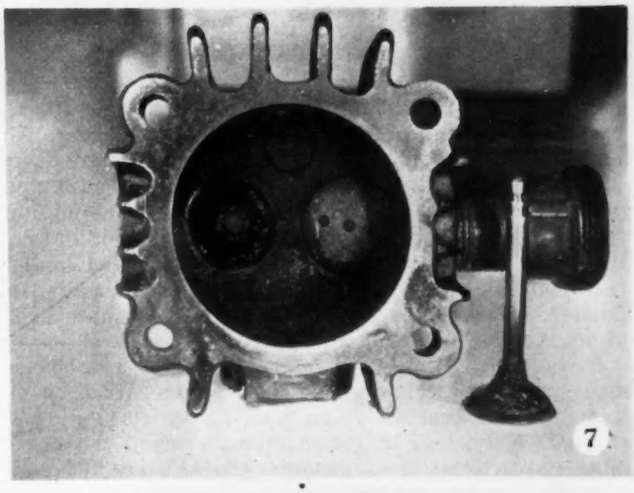
TABLE 1—SUMMARY OF ENGINE TESTS FOR GUM IN GASOLINE

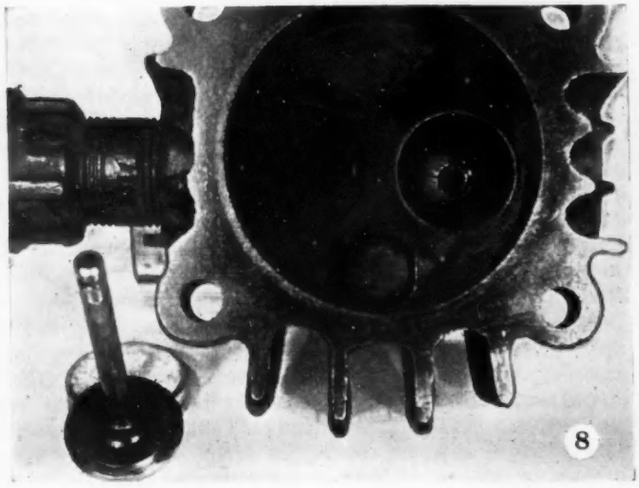
Run No.	Fuel Used	Gum by Steam-Oven Test, Mg. per 100 CC.	Gum by Oxygen Gum Test, Mg. per 25 CC.	Gum by Copper-Dish Test, Mg. per 100 CC.	Weight of Deposit in Inlet Passage, Grams	Weight of Carbon Deposit on Cylinder-Head, Grams	Engine Speed, R.P.M.	Engine Load, Hp.	Length of Test, Hours	Remarks
1	Commercial Gasoline, No. 1	4	3	10	0.00	...	1260	0.45	16¼	No gum deposit in inlet passage or in cylinder
2	Vapor-Phase Gasoline, No. 2	7	6	65	0.00	...	1370	0.45	16¾	No gum deposit in inlet passage or in cylinder
3	Vapor-Phase Gasoline, (1 yr. old) No. 3	120	520	665	3.99	3.29	1240	0.75	17¼	See photograph of cylinder-head and valve after test; valve sticking
4	Vapor-Phase Gasoline, No. 4	22	380	188	0.94	1.57	1230	0.80	21¼	Some gum deposit inside of cylinder-head
5	Vapor-Phase Gasoline, No. 5	17	360	237	0.41	3.38	1220	0.83	23¾	Some gum deposit inside of cylinder-head
6	Fuel No. 6 (50 per cent Fuel No. 4 and 50 per cent Fuel No. 1)	11	...	110	0.17	1.93	1240	0.85	19	Slight trace of gum on inlet valve
7	Commercial Gasoline, No. 2	4	...	19	0.00	...	1310	1.10	16¾	No gum deposit in inlet passage or in cylinder
8	Fuel No. 8-A (Fuel No. 1 with dissolved gum)	39	...	69	0.29	4.84	1230	0.93	17¾	Considerable gum deposit inside of cylinder-head
9	Fuel No. 8-B (Fuel No. 1 with dissolved gum)	12	...	46	0.12	3.09	1260	0.87	17¼	No gum deposit inside of cylinder-head
10	Vapor-Phase Gasoline, No. 9	4	150	51	0.00	...	1280	0.98	15¾	No gum deposit in inlet passage or in cylinder
11	Vapor-Phase Gasoline, No. 11 (freshly distilled)	8	850	712	0.00	1.29	1280	1.01	19¾	No gum deposit in inlet passage or in cylinder
12	Fuel No. 8-C (Fuel No. 1 with dissolved gum)	18	...	32	Trace	1.17	960	0.00	28	Trace of gummy deposit on inlet valve
13	Same as Fuel No. 8-C	18	...	32	0.27	1.24	1220	0.98	19½	Some gum deposit inside of cylinder-head
14	Vapor-Phase Gasoline, No. 10	12	170	453	0.09	3.04	1240	0.71	19	No gum deposit inside of cylinder-head
15	Fuel No. 12-A (Fuel No. 1 with dissolved gum)	26	...	81	0.20	2.88	1230	0.75	19½	Considerable gum deposit inside of cylinder-head

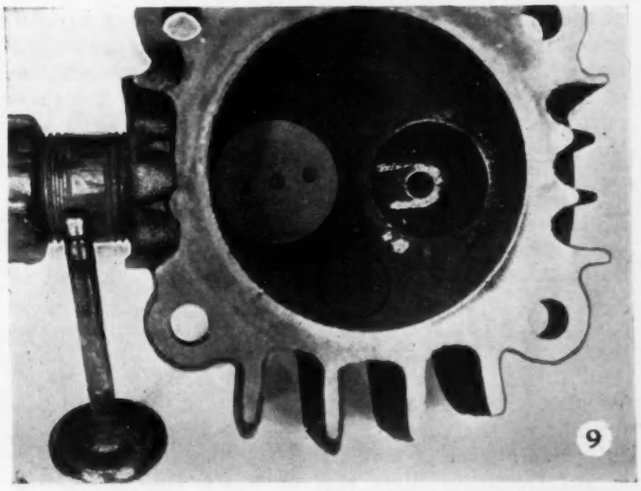












Engine Test Results on Different Fuels, Showing Wide Variation in Amount of Gum Deposited

Fig. 4—Test on Fuel No. 8-A; Gum by Steam-Oven Test, 39 Mg. per 100 Cc.; by Copper-Dish Test, 69 Mg. per 100 Cc. Soluble Gum Added to the Fuel Seemed to Have a Tendency To Run into the Cylinder, Leaving Only a Small Amount Adhering to the Inlet Passage and Valve

Fig. 5—Test on Fuel No. 12-A; Gum by Steam-Oven Test, 26 Mg. per 100 Cc.; by Copper-Dish Test, 61 Mg. per 100 Cc. Soluble Gum Had Been Added. Results of the Steam-Oven Test May Ordinarily Be Used To Predict the Amount of Gum Deposition and the Trouble That Will Result if the Test Is Made at the Time the Gasoline Is Used

Fig. 6—Test on Fuel No. 8-B; Gum by Steam-Oven Test, 12 Mg. per 100 Cc.; by Copper-Dish Test, 46 Mg. per 100 Cc.

Fig. 7—Test on Fuel No. 3; Gum by Steam-Oven Test, 120 Mg. per 100 Cc.; by Copper-Dish Test, 665 Mg. per 100 Cc.

Fig. 8—Tests on Fuel No. 8-C; Gum by Steam-Oven Test, 18 Mg. per 100 Cc.; by Copper-Dish Test, 32 Mg. per 100 Cc.; Inlet-Manifold-Wall Temperature, 135 Deg. Fahr. Only a Small Trace of Gummy Deposit Was Left After a Run at This Temperature Under No-Load Conditions

Fig. 9—Another Test on Fuel No. 8-C, Run Under the Same Conditions Except that the Inlet-Manifold-Wall Temperature Was 175 Deg. Fahr. A Much Greater Deposit Was Shown at the Higher Temperature, and It Was Decidedly Hard and Brittle

The main reason that the deposit of gum, which in some cases was excessive, did not cause any great sticking of valves was that the overhead-valve construction of the engine caused the gum to run down and collect mostly on the under side of the valve-head instead of on the valve-stem, sometimes actually running into the combustion-chamber. It seems logical to suppose, therefore, that valve-sticking would manifest itself sooner in the L-head engine. However, in the overhead-valve engine, the inlet valve may be held open by gum running over the valve-seat.

The amount of deposit inside the cylinder-head (see Table 1) does not seem to be in any way related to the gum content of the fuel used. The variation in this deposit from run to run is probably due to differences in engine operating conditions and overshadows any effect that may be due to gum.

Permissible Limits for Gum

Only scant references to the amount of gum that can be tolerated in a motor fuel are contained in the literature. The Bureau of Mines, describing the copper-dish test, states[7] that the fuel should not give more than 0.03 per cent gum by this test. This amounts to 22 mg. per 100 cc. The Government specification for aviation fuel, domestic or fighting grade, is 3 mg. per 100 cc. W. Ostwald[8], of Germany, in a paper presented to the fuel conference of the World Power Conference in London, states that a fuel should not contain more than 50 mg. of gum per 100 cc.

It should be pointed out that no distinction has been made in these specifications between gum already contained in the fuel and gum which may form during storage. Obviously, a specification covering the gumming characteristics of gasoline should state the permissible gum-content at the time of use, as an indication of the suitability of the gasoline for engine fuel; and it should also specify gum stability, as an indication of the length of time the gasoline will remain free of gum while in storage. It is apparent that for these purposes no single test will suffice. We believe that this paper describes satisfactory and reproducible tests for both gum content and gum stability in the steam-oven test and the oxygen gum-test, respectively. (See Appendix).

An effort has been made in this work to determine the maximum quantity of preformed gum that can be permitted in a fuel without seriously affecting engine operation. The results are admittedly incomplete, but they seem to indicate that under most conditions more than 10 mg. of actual gum per 100 cc. at the time of use may produce a noticeable deposit in the inlet passage and on the valves. As the tests were made on an air-cooled engine in which the inlet manifold and valve temperatures are high, and in which gum deposition would be expected to be most serious, we believe that this limit for actual-gum content is very conservative. The work on the Delco engine has been more or less substantiated by actual car tests on the road. A new four-cylinder passenger-car was operated for 1068 miles, using 78 gal. of a gasoline which had shown a copper-dish test of 351 mg. of gum per 100 cc. and a steam-oven test of only 6 mg. per 100 cc. It gave good performance and showed no signs of deposits on the inlet valves. A similar test on the same fuel in a six-cylinder passenger-car showed the same results.

TABLE 2—ABILITY OF OXYGEN GUM-TEST TO PREDICT GUM STABILITY

Sample	Oxygen Gum-Test, Mg. per 25 CC.	Time of Storage, Months	Actual Gum Formed, Mg. per 100 CC.
26	410	21	168 (gum separated)
23	465	21	612
22	4.6	21	6
24	0	21	1.4
27	252, 246	8	48, 36
28	3, 4	8	8, 10
29	2, 2	8	2, 2

A car test was also made on a low-gum gasoline to which had been added 26 mg. of soluble gum per 100 cc. No particular trouble was encountered from sticking valves while driving 618 miles in a six-cylinder passenger-car and using 45 gal. of this gasoline. It is realized that this quantity of gasoline consumed is relatively small; nevertheless, when the engine was taken down there were slight gummy deposits on the under side of the inlet-valve heads and deposits on the cylinder-head around the inlet valves that were due to gum. There was also a localized spot of gum formation, about 1 sq. in. in area and about 1/32 in. thick, in the vertical riser of the inlet manifold above the carbureter. This part of the manifold is exhaust-jacketed and operates at a relatively high temperature, which probably accounts for gum being found there. Similar deposits of gum on hot spots of the inlet manifolds of other cars are known, especially in the case of those well-known four-cylinder cars using a hot-plate vaporizer. The condition of the cylinder-head of the passenger-car engine after the test just referred to was not quite as bad as that of the Delco engine when using the same fuel (see Fig. 5), probably primarily because of the differences in the operating temperatures of these engines.

It is not so easy to fix the limit for potential gum or gum stability, as this involves the time of storage at the refinery, at the bulk station, and in the distributor's and the consumer's tanks. Because of the great variation in the time of storage, it is obvious that a satisfactory stability test must be rigid enough to ensure that excessive amounts of gum will not be formed in any reasonable period of storage. The oxygen gum-test previously mentioned, which is a measure of the potential gumming properties of a fuel, has been developed for this purpose, but data giving direct comparison between the predictions by this test and actual gum-formation after storage are rather meager. Some of the results obtained are given in Table 2. They seem to indicate that a gasoline which forms less than 10 mg. of gum per 25 cc. in the oxygen gum-test will not form enough gum during storage for at least a year to impair its value.

Research on this whole problem of gum is being further carried on in the form of additional laboratory work and, finally, road testing. The question of gum gasoline probably will tend to become more serious as the demand for antiknock fuels increases.

APPENDIX

Little is known concerning the chemistry of resin formation in gasoline, except that oxidation is an important part of the process. As far back as 1915,

[7] See Bureau of Mines Technical Paper 214.

[8] See *Oil and Gas Journal*, Nov. 22, 1928, p. 123.

TABLE 3—RELATION BETWEEN OXYGEN ABSORPTION AND GUM FORMATION—GASOLINE SAMPLE 20

Experiment No.	Time of Oxidation, Minutes	Weight of Gum, Grams	Weight of Oxygen Absorbed per 100 CC., Grams	Ratio of Oxygen to Gum
1	105	0.298	0.392	1.31
2	145	0.932	1.040	1.12
3	150	0.961	1.080	1.12
4	363	2.758	3.370	1.22

William A. Hall read a paper[9] before the Institute of Petroleum Technologists which showed a remarkable insight into the problems of petroleum cracking and refining as they affect engine performance. Referring to the resin in vapor-phase gasoline, he said: "It appears to be a product of slow oxidation, for if . . . kept in a receptacle with air, a resinous red-varnish deposit is formed . . . and the whole mass has a varnish-like odor."

This odor is also characteristic of vegetable drying-oils and seems to be associated with organic peroxides. B. T. Brooks[10] believes that gum in gasoline is merely the end product of polymerized peroxides. The necessity for oxygen in gum formation has also been shown by Smith and Cooke[11]. Cooke[12] later showed the necessity of evaporating gasoline samples in the absence of air when determining the non-volatile residue, and developed a test for this purpose. This test has been used with some modifications, described later, and has given very satisfactory results as a measure of the gum actually present at a given time. It should be emphasized, however, that the method does not indicate how much gum may be formed during storage; that is, it does not measure the gum stability of a gasoline.

Oxygen Absorption and Gum Formation

On the assumption that gum formation during storage was the result of slow oxidation, samples were shaken in a long-necked pyrex flask surrounded by steam and connected to a mercury manometer and an oxygen burette, as shown in Fig. 10. The rate of oxidation could be easily followed by observing the fall in pressure. Many different gasolines varying widely in their susceptibility to oxidation were tested in this way. In all cases, however, there ensued a distinct induction period, during which the oxidation rate was very slow and relatively constant.

Fig. 11 shows the types of curves obtained with gasolines of different oxidation susceptibilities. This phenomenon suggests that the oxidation of gasoline is of the autocatalytic type and that the differences between different samples are more in the length of the induction period than in the rate of oxidation, once this has passed. It is obvious, therefore, that the resistance of a gasoline to oxidation can best be measured by the duration of the induction period. When this has passed and oxidation is well begun, the time required for the formation of a large amount of gum is very short and the more stable stocks oxidize at about the same rate as the unstable ones. Furthermore, the amount of gum which can be formed seems to depend only on the oxygen supply and the time of heating, at least within reasonable limits. In one experiment 12 per cent of gum was obtained, with no indication of decreasing oxidation rate.

When these oxidized samples were evaporated in a steam atmosphere, it was found that, for any given gasoline, a relatively constant relation existed between the weights of gum produced and of oxygen absorbed.

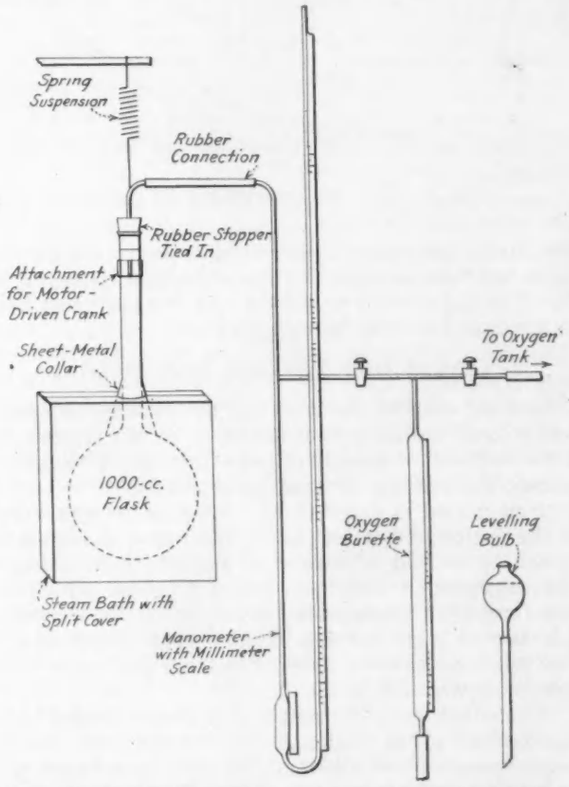


FIG. 10—DIAGRAM OF OXYGEN-ABSORPTION APPARATUS

This indicates that gum formation, at least under these conditions, is a result of oxidation only. Typical data are given in Table 3.

Modified Steam-Oven Test

A modification of Cooke's steam-oven evaporation test was used for the determination of the gum content of a gasoline at any given time; that is, the amount already in solution. The oven used was a sheet-metal box placed within a Freas electric oven. A slow current of steam was led into the bottom of this box through a perforated pipe and escaped at the top. Fifty-cubic-centimeter samples of gasoline were used, instead of 20-cc. samples, as described by Cooke, so as to obtain greater accuracy with low-gum gasolines. They were evaporated in 200-cc. pyrex dishes placed on a shelf in the oven. When the gum content is excessive, the gum has a tendency to creep down the outside of the dishes, but loss is prevented by supporting the dishes at three points. The temperature was kept at 320 to 350 deg. fahr., as it was found that at this temperature samples could be evaporated to constant weight in 10 hr., whereas at lower temperatures a much longer time was required. In one experiment at 212 deg. fahr., it was not possible to attain constant weight in 48 hr. Cooke used

[9] See *Journal of the Institute of Petroleum Technologists*, 1915, p. 147.

[10] See *Journal of Industrial and Engineering Chemistry*, 1926, p. 1198.

[11] See Bureau of Mines Report, Serial No. 2394, 1922.

[12] See Bureau of Mines Report, Serial No. 2686, May, 1925.

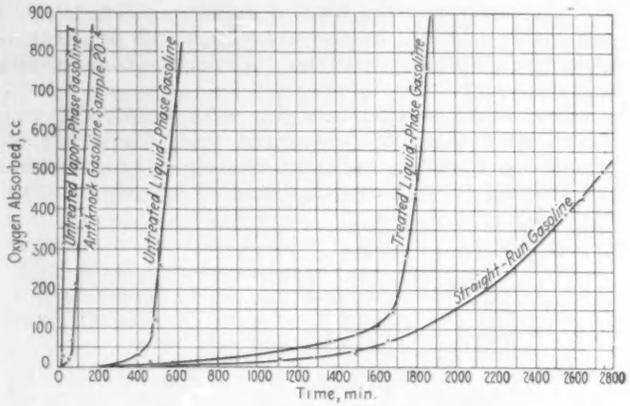


FIG. 11—OXYGEN ABSORPTION BY GASOLINE

wet steam but completed evaporation in an air oven. This has been avoided in our experiments, as it was found that the resin would take up oxygen when heated in air and increase in weight.

Oxygen Gum-Test and Gum Stability

Another method devised for the routine determination of gum stability is referred to as the oxygen gum-test. Instead of measuring the amount of oxygen absorbed, the amount of gum produced after heating for a given period is determined. Five hours was selected as the period of heating, as it was found that gasolines known to be bad offenders as regards gum formation were appreciably oxidized, and that those which were free from gum trouble even when stored for a considerable period were not oxidized in this length of time. The relation between time of heating and gum formation is shown in Fig. 12.

The actual test is made as follows: round-bottom long-necked pyrex flasks of 500-cc. capacity are carefully cleaned with acid and distilled water and dried by heating and aspirating. After filling the flask with oxygen, the gasoline sample is run in from a 25-cc. pipette. Since pressure is developed on heating, it is necessary to close the flask with a rubber stopper, tied on. The flasks are placed in an actively boiling steam-bath, allowing only the necks and stoppers to protrude. After heating for exactly 5 hr., they are cooled and the contents transferred to dishes and evaporated in the steam oven. It is necessary to rinse the flasks to transfer precipitated gum. For this purpose a mixture of benzene and alcohol has been found suitable, as it is an excellent solvent and has no effect on the subsequent evaporation. Stable gasolines have given from 2 to 10 mg. of gum (8 to 40 mg. per 100 cc.) by this test, whereas unstable stocks have given as high as 500 mg. of gum.

TABLE 4—GUM DETERMINATION BY THE OXYGEN AND THE COPPER-DISH METHODS

Sample No.	Gum per Sample, Milligrams	
	Oxygen Gum Test	Copper-Dish Test
16	55, 52	42, 36
17	44, 44	64, 162
18	456, 525	520, 517
19	3, 4	13, 18
20	257,246 266,269	58, 67 144, 114 39, 91
21	40, 40	316, 372

TABLE 5—COLOR AND GUM CONTENT

Sample	Actual Gum, Steam-Oven Test, Mg. per 100 CC.	Color, Saybolt
22	6	10
23	612	18
24	1.4	25
25	1240	—17

Gum-Stability Determination by Copper-Dish and Oxygen Methods

The objections to the copper-dish test are the poor reproducibility because of lack of oxidation control, the failure to discriminate between gum already formed and that formed during the test, and the possible catalytic effect of copper, which is not usually encountered in actual storage. Another disadvantage of this method of predicting gum stability is that the volatile portion of the sample evaporates rapidly and is thus exposed to atmospheric oxidation only a short time. A gasoline of high end-point will give a great deal more gum than one of low end-point, although made from the same stock. In storage, however, the light portion will form gum just about as rapidly as the heavy portion. Therefore, even if the copper-dish test could be standardized to give concordant results, the results would vary a great deal with the volatility of the gasolines being tested. However, with all the variables mentioned, the copper-dish test can be used with a fair degree of accuracy to predict the gum stability of gasoline, as shown by Table 4.

This table shows that the oxygen-gum method gives more consistent results than the copper-dish method, although the results are, in general, of the same order. For distinguishing between fuels that are very stable or very unstable, the latter method gives results which are satisfactory, but it is not reliable for purposes of standardization.

Color and Gum

About the only excuse for a color specification for motor fuel is that color is often a measure of the degree of refining. It is well known, however, that many of the present antiknock fuels are of poor color yet give satisfactory performance with respect to gum. Some of the fuels tested by the writers, with colors below —17 Saybolt, caused no gum deposition in the engine.

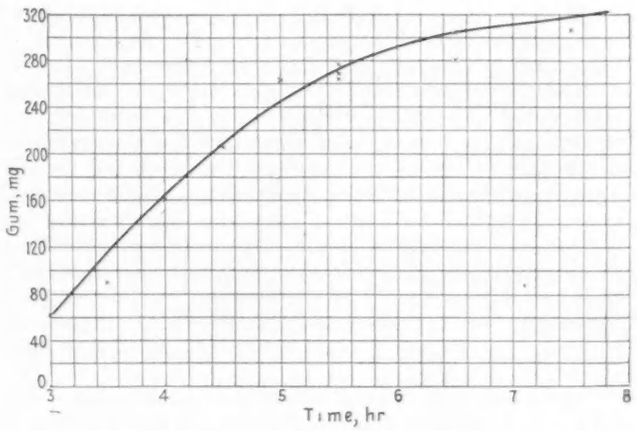


FIG. 12—RATE OF GUM FORMATION IN THE OXYGEN GUM-TEST

On the other hand, it is possible for a gasoline to be of good color but have an exceedingly high gum-content. Table 5 shows the lack of correlation between gum and color of several samples of gasoline that had been in storage in dark bottles for two years.

Sunlight Test

Another test sometimes used is the sunlight test. Certain gasolines, when exposed to light in a glass bottle, will deposit a layer of resin. This has been taken as a measure of gum stability, but it has little value, since much of the gum formed in gasoline is soluble and does not precipitate. Furthermore, it is not essential that gasoline, which is usually stored away from light, be light-stable; and many stocks are known which are gum free and perfectly stable but which will deposit gum when placed in the light for a short time.

THE DISCUSSION

J. B. HILL[13]:—When Mr. Eisinger and Mr. Voorhees presented some of the results of their work at the American Petroleum Institute meeting in Chicago in December, some of us were very much interested in their conclusions that the gum content formed in the engine was dependent only upon the content at the time the gasoline enters the fuel-induction system and does not bear any relation to oxidation or polymerization during vaporization. We went home from that meeting determined to see what results we could get ourselves, because the conclusion seemed rather startling.

We were using at that time a gum test designed to show the presence of gum derived from oxidation. It consisted of a chromium-plated dish, heated to about 400 deg. fahr., into which we atomized the gasoline at a fixed rate, thinking that in that way we would perhaps duplicate the conditions existing around the inlet valves. Since that meeting we have made a rather careful, but necessarily brief, series of comparisons of the modified steam-oven test, as Mr. Eisinger has described it, and our chromium-plated-dish test. Considerably to our surprise, we find they line up very well; that is, the chromium-plated dish apparently does not give the oxidation we expected, which confirms Mr. Eisinger's conclusions. It seems to show that there is no oxidation under those conditions in the short time the test is being made.

We are still somewhat surprised by the considerable quantities of gum these investigators have obtained in this work in the engine test. We have been making engine tests recently with gasoline having about 30 mg. of gum content per 100 cc. on the steam-oven test, which is above Mr. Eisinger's limit. We have been using it in a four-cylinder engine, about 3¼ x 4½, L-head construction. We determined to run the engine on this gasoline until we got into serious trouble. The sample of gasoline we had available amounted to 700 gal., all of which was used without getting into any trouble. When the engine was taken apart and carefully examined, the manifold and inlet valves showed no deposit at all.

Relation of Heat to Gum Deposition

D. A. GAUTHIER[14]:—We have had trouble with some constitutent of gasoline collecting on the float-valve in the carbureter and causing it to stick to its seat. From this discussion, I believe that the gum referred to causes the trouble.

F. G. WHITTINGTON[15]:—Mr. Eisinger spoke primarily of the condition of heat in connection with gum deposit. The first indication we ever had of gum deposit was in locations where there was no heat. I wonder if this deposit is increased where heat is present or if the percentage of deposit would be the same whether or not heat was present.

Our attention was first drawn to the subject by a complaint about six months ago regarding sticky flapper valves in vacuum tanks; and upon checking several of these tanks and making an examination, we found a fine deposit on the flapper valves. Enough could not be collected, however, to make an analysis. Immediately thereafter we learned a little about the existence of gum in gasoline.

I should like to know the precise relationship of the gum deposit to the very high heat-condition in most of the tests dealt with by the authors of the paper.

I should also like to ask about the increase of gum content with the storage of gasoline. Are we to understand that the gum content continues to increase during storage? If so, what chemical action occurs or what manufactures that gum during storage?

JOHN O. EISINGER:—One of the tests reported was made at a somewhat lower manifold-wall temperature. At the higher temperatures the deposit was harder and more deposit formed than at the lower temperature, which shows that temperature is a factor. Gum deposition in the carbureter and other relatively cool parts will be less than in the intake system, when using a gum-forming gasoline.

The appendix to the paper takes up Mr. Whittington's second question regarding the formation of gum in storage and the reason for it. Different gasolines form gum at different rates, depending upon how they are made. Most of them have a very decided induction period, as we call it, during which the oxidation of the gasoline, and the consequent gum formation, is very low. After the induction period, which may be from one to six months or more, depending upon the gasoline and the storage conditions, the rate of gum formation is relatively high.

DALTON RISLEY, JR.:—Are all these fuel gums more prevalent at the inlet valve and, if so, why are sticky exhaust-valves more common than sticky inlet valves?

MR. EISINGER:—I cannot answer that. Our experience has been the reverse; that the inlet valve gives the trouble.

Pistons and Exhaust Valves Not Affected

W. G. WALL[16]:—Most of us think we are able to distinguish between carbon deposited on the pistons by fuel and that caused by the oil. Also, when piston-rings

[13] M.S.A.E.—Chief chemist, Atlantic Refining Co., Philadelphia.
[14] Jun. S.A.E.—Service engineer, carbureter division, Penberthy Injector Co., Detroit.
[15] M.S.A.E.—Chief engineer, Stewart-Warner Speedometer Co., Chicago.
[16] M.S.A.E.—Consulting engineer, Indianapolis.

stick, we lay it as a rule to the lubricating oil. I wonder if a large quantity of gum in the fuel would not give an entirely different appearance to this carbon so that it would appear very much like the carbon that would result from excess lubricating oil coming up past the rings, and if the sticking of any of the rings really is due to gum and not to lubricating oil. We have charged so many things against lubricating oil that it would be almost a relief to find that it is not giving all the trouble attributed to it.

MR. HILL:—We have been getting along in the past with virtually no gum trouble from gasoline. It is a subject which has just begun to open up with some of the very high-antiknock vapor-phase cracked gasoline.

I do not think the troubles referred to by Mr. Risley and Colonel Wall are due to gasoline. Our evidence all seems to show that any gum trouble that happens occurs in the fuel-induction system up to and including the inlet valve. Whatever gum is present apparently has done its damage by the time it reaches the cylinders, and we believe there is very little possibility of any of it getting beyond the inlet valves. I think the exhaust-valve and piston troubles undoubtedly are caused by lubricating oils.

O. C. BERRY[17]:—Is it possible to remove the preformed or dissolved gum from gasolines containing it so that it will not change the calibration of our carbureters in a short time and cause carbon deposition in our engine cylinders? Is there any simple treatment by which the ordinary man who buys gasoline can take that gum out and make the gasoline suitable for use in our engines?

MR. EISINGER:—I am inclined to think from our present knowledge on this subject, that the gum is in such a state that it would be very difficult to remove without a lot of trouble. It can be done, but I doubt very much whether the average man would want to go to the trouble of doing it.

MR. WHITTINGTON:—Are we to be alarmed that trouble caused by gum will increase, or is this a matter of investigation for the purpose of preventing such trouble?

MR. EISINGER:—I think there is no reason to become alarmed at present. However, if the car manufacturers keep on increasing their compression ratios, the gasoline manufacturers are going to try to make antiknock fuels, some of which may give gum troubles.

CHAIRMAN GEORGE A. ROUND[18]:—It has been our experience that, if the temperature is high enough, any oil can be oxidized and will form gum. For example, we have found that oils which are performing satisfactorily in some American makes of aircraft engine give troubles from piston-ring gumming in some European engines. The difficulty comes from the fact that the European engines in question do not seem to be as well cooled as those of American manufacture. This condition can be alleviated to some extent by changes in the refining processes, but apparently no oil no matter how perfectly refined is immune to gumming if the temperatures are high enough.

[17] M.S.A.E.—Motor engineer, Buick Motor Co., Flint, Mich.

[18] M.S.A.E.—Assistant chief engineer, engineering division, automotive department, Vacuum Oil Co., New York City.

Changing Farm Conditions

SEVENTY or 80 years ago farming underwent a revolutionary change from handpower to horsepower. It is now undergoing another change, no less revolutionary, in character of implements and the use of power. The most outstanding of these new implements is the combined harvester and thresher, which is rapidly coming into use and effects a very substantial saving in the cost of producing the small grains.

Plowing always has been one of the biggest jobs on the farm. One man, with two horses and a single-bottomed plow, could scarcely plow 2 acres per day, but one man with a tractor will plow 8 to 10 acres per day. Until a few years ago the standard implement for cultivating corn was the single-row cultivator, operated by one man and two horses, but in the last season a three-row cultivator has been in successful use, operated by one man and a tractor or equal horsepower. Practically the entire list of farm implements is undergoing change in a manner which greatly increases the effectiveness of manpower.

Friends of the horse by no means give up the field to the tractor. They claim that multiple hitches, using six, ten, and even more horses, are economically successful. The point is that machinery of higher capacity for all farm work is coming into use.

A few years ago the agricultural-implement business was facing as discouraging a prospect as can be imagined, but today it is enjoying one of the greatest periods of prosperity in its history.

The significance of all this is that the costs of production on the farms, in terms of manpower, are being reduced, that a smaller number of workers on the farms will be able to produce the required supply of farm products, and that unless further expansion of farm area occurs the business will be more remunerative. The release of agricultural workers is simply a continuance of a process which has been going on throughout the history of agriculture. A constantly diminishing percentage of the population has been able to supply the required quantity of farm products. The general rise of the standard of living of the masses consists in the main of the increased supply of things other than farm products, and these are to be found in the farm homes as well as elsewhere. The conditions in industry are always changing, and the people in every industry must adapt themselves to the changes. Any other conclusion would mean industrial and social stagnation.

If, instead of rapidly increasing the area of land under cultivation, the farm workers who are released by the new machinery will find employment in other industries, the production of the farm staples will not be rapidly increased, farm land values will be stabilized and the benefits of the new machinery at least shared by the farmers.

A great proportion of the farmers are prosperous today, but an important section are on the border line between existence and bankruptcy.—From an address by George E. Roberts, vice-president National City Bank of New York.

Dual Carburetion and Manifold Design

By F. C. Mock[1]

Annual Meeting Paper — *Illustrated with* Charts and Drawings

DUAL carbureters, as equipment for eight-cylinder passenger-car engines, have recently come into special prominence and, compared with a single carbureter, give a gain in power in the middle-speed range, between 1400 and 2800 r.p.m. This is an adaptation from airplane-engine practice, in which greater power-output and better distribution have been realized by multiplying carbureter units as the number of cylinders is increased. An absence of overlapping and interfering suction-strokes and the use of larger manifold-passages are apparently responsible for this gain.

Tests made on a number of eight-cylinder engines of both the in-line and the V-types confirmed this gain, which was, however, unaccompanied by any particular gain in fuel economy. With dual manifolding, the weight and heat-capacity of the manifold mass are high in proportion to the piston displacement, with a resultant lag in mixture temperature, as compared with changes in the manifold temperatures, the extremes of the former being greater than in other engines.

While the dual carbureter has been blamed for inability of the engine to idle smoothly and for poor fuel-economy at light loads, the substitution of a single carbureter on the selfsame engine failed, in virtually every case, to improve either condition.

Carburetion problems are relatively simple with the dual system. Low velocities can be used, and a nearly uniform mixture gives good results except at low speeds. Some minor variations between the suction and the airflow of the two carbureter barrels result from the difference in the length and volume of the two manifold members. In service, some difficulty was experienced at first in securing a satisfactory setting of the two idling adjustments.

Dual carbureters have not successfully replaced the single system on six-cylinder engines because of "blow-back of fuel spray and air charge from the mouth of the carbureter." This condition probably can be remedied by a slight change in the valve timing.

The discussion covers the necessity for overcoming spiralling of the airstream, the increase in aircraft-engine power-output following the change from a six-cylinder manifold to a three-cylinder grouping and the "ramming" and blowback effects in six and eight-cylinder engines.

MULTIPLYING carbureter units with increase in the number of cylinders is not new; in airplane-engine practice, in particular, greater power-output and better fuel-charge distribution have been realized by increasing the number of carbureter units as required to avoid overlapping suction-strokes and yet maintain even suction intervals. In motor-car practice the multiple carbureter has come into special prominence as equipment for the eight-cylinder engine, to which, as compared with a single carbureter, it seems to contribute a definite gain in power in the middle speed-range, from 1000 to 3000 r.p.m.; a less marked gain in power at high speed; little if any saving in fuel consumption; and, in the opinion of nearly every driver, a "feeling" of smooth free pulling at full load and more willing response to the throttle that can be ascribed to better distribution and naturally more favorable conditions of carburetion.

In the preparation of this paper I wrote to a number of American manufacturers who had been experimenting with single and dual-manifold systems on eight-cylinder engines, requesting power comparisons and permission to make them public. Each company addressed responded generously, for which I wish to express my appreciation and thanks.

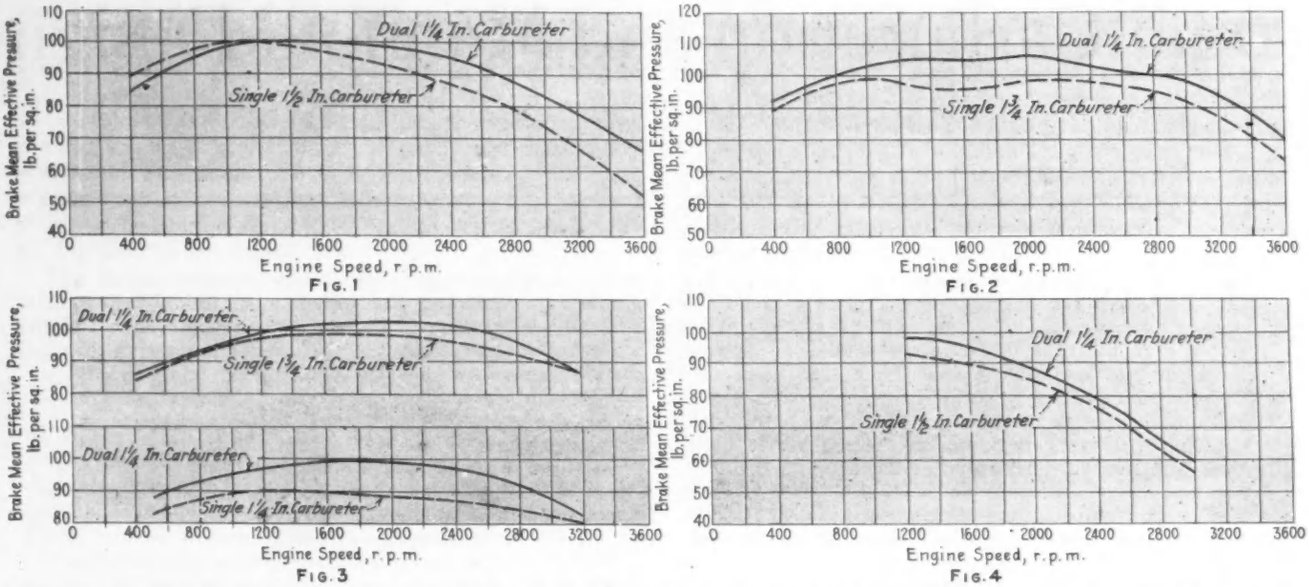
The Effect on Power

Fig. 1 shows a typical comparison of power curves obtained with 1½-in. single and 1¼-in. dual carbureter systems on one of our leading eight-cylinder-in-line cars. The setting of each carbureter had been developed from thorough tests, which involved also changes of manifold diameter and shape. It will be noted that the torques were equal at 1200 r.p.m., that the dual system gained about 10 per cent at 2400 r.p.m., and about 26 per cent at 3600 r.p.m. This differs from the comparison obtained with some other engines in that the gain increases with the engine-speed. In the car, the single system felt a little more "solid" below 7 m.p.h., both were about alike from 7 to 20, and above 20 m.p.h. the dual carbureter gave the feeling of considerably more power, just the difference between an ordinary automobile and a rather superior one. The second-gear acceleration of the dual system was much faster. I believe the dual system gave 4 or 5 m.p.h. greater maximum speed; exact comparisons of this character are always difficult to obtain.

Fig 2 shows power curves obtained on another well-known eight-cylinder-in-line engine with a 1¾-in. single and a 1¼-in. dual carbureter. These curves show that the latter is better all along the line; 3½ per cent at 400 r.p.m., 7 per cent at 1200 to 2400 r.p.m., and 8½ per cent at 3600 r.p.m. The improvement in car performance was about that described in the first instance, except that not more than 3 m.p.h. was gained in maximum speed.

Fig. 3 shows curves of two engines that have slightly different characteristics. Here the gain in torque is confined to the region between 1000 and 3200 r.p.m., and in working with these engines we found the rather peculiar fact that, whereas we could bring the power of the engine equipped with the single carbureter up to that of the engine with the dual carbureter at 3600 r.p.m. by putting a large air passage in the carbureter.

[1] M.S.A.E.—Research engineer, Stromberg Motor Devices Co., Chicago.


Brake Mean Effective Pressure, lb. per sq. in.
Dual 1¼ In. Carbureter
Single 1½ In. Carbureter
Engine Speed, r.p.m.
Fig. 1
Brake Mean Effective Pressure, lb. per sq. in.
Dual 1¼ In. Carbureter
Single 1¾ In. Carbureter
Engine Speed, r.p.m.
Fig. 2
Brake Mean Effective Pressure, lb. per sq. in.
Dual 1¼ In. Carbureter
Single 1¾ In. Carbureter
Dual 1¼ In. Carbureter
Single 1¼ In. Carbureter
Engine Speed, r.p.m.
Fig. 3
Brake Mean Effective Pressure, lb. per sq. in.
Dual 1¼ In. Carbureter
Single 1½ In. Carbureter
Engine Speed, r.p.m.
Fig. 4

POWER COMPARISONS OF EIGHT-CYLINDER ENGINES EQUIPPED WITH SINGLE AND DOUBLE-CARBURETER SYSTEMS SHOWING A GAIN WITH THE LATTER AT INTERMEDIATE AND HIGH SPEEDS

Fig. 1—A Well-Known 1929 In-Line Engine

Fig. 2—Another In-Line Engine

Fig. 3—Two More In-Line Engines

Fig. 4—A V-Engine with Four Crank Throws Spaced at 90 Deg.

no such enlargement, within practical limits, would bring the former up to the latter at 2400 r.p.m. We have experienced this a number of times, and, making allowance for the natural difference to be expected between engines, it seems that, while the gain in power with the dual system at maximum speed may be ascribed to the freer air-delivery, the gain at intermediate speeds must be due to something else, probably the elimination of overlapping suction-strokes.

Gain in Intermediate Car-Speed

A rather interesting test of actual performance was obtained with two cars having engines whose curves are shown in the lower part of Fig. 3. With the single manifold and carbureter on one car and the dual system on the other, the cars were driven side by side on a level concrete road at 5 m.p.h., and at a given signal both throttles were opened wide. Neither gained a yard until a 20-m.p.h. speed was reached, but at this point the dual-manifold car began to draw ahead, gaining about four car-lengths by the time a speed of 40 m p.h. was attained. Beyond this speed it gained less rapidly, and finally the two cars settled to a constant distance of about six car-lengths apart. The carbureters and manifolds were then interchanged and the test repeated, with substantially the same result. This checks with what we have found from other tests, that a given gain of torque is more advantageous to car performance if it comes in the intermediate speed-range than if it comes only at maximum speed.

Fig. 4 is a comparison similar to the preceding, made on an eight-cylinder V-type engine with four crankshaft-throws 90 deg. apart. The firing order was such that one 90-deg. overlap of suction strokes occurred in the sequence of the four cylinders of each bank, as fed by one barrel of the 1¼-in. dual carbureter. A 5/16 x ⅝-in. balancing port, located at the junction of the manifold and carbureter, connected the two manifolds of the dual system. The engine is reported to have shown better power, smoother running and slightly better idling than with a single manifold and ¼-in. larger single carbureter of the same type.

Altogether, out of nine different eight-in-line engines tested with single and dual carbureters, eight showed definite gains in power, seven showing values such that the dual equipment was adopted. One engine, however, with a very creditable high-speed performance both on the dynamometer and in the car, seemed to show a little less power at high speed with a 1¼-in. dual carbureter than with a 1¼-in. single carbureter, while the gain with the dual in the intermediate range was only 4 or 5 per cent. The size of valves and the timing on this engine were such that with the dual carbureter a very marked "blowback" of fuel spray out of the air entrance of the carbureter occurred, to the extent that its use would have been dangerous. Trial of balancing ports between the dual manifolds reduced the blowback, brought the power up to that developed with the single carbureter at maximum speed and down to that at intermediate speeds. It seems probable that the dual system would have performed better with a different valve timing, with perhaps earlier closing of the intake valve.

Application to Six-Cylinder Engines

With dual manifolds on six-cylinder engines, a definite interval of absolutely no induction between suction strokes occurs, which develops or permits a blowback of fuel spray out of the entrance to each carbureter barrel, if the customary high-speed intake-valve timing be used. On slower-speed marine and heavy-duty engines, with intake valves closing not later than 35 deg. past bottom center, this blowback has been barely noticeable. In the few efforts we have made to fit dual carbureters and manifolds on high-speed six-cylinder motor-car engines, very little gain in torque has been realized. The violent blowback suggests that power would be gained if this

charge rejection were stopped, for instance by closing the intake valve earlier.

One carbureter barrel for each three cylinders, in either 6 or 12-cylinder engines, with intake valve closing at about 42 deg. after bottom center, is almost the universal practice in aircraft engines. Under these conditions blowback is dealt with by turning the entrance of the carbureter toward the propeller so that its blast keeps the fuel spray from blowing out.

Reasons for Power Gain

Considering the energy of airflow in the intake manifold during the suction stroke of one cylinder alone, the induction of air may be termed to some extent potential in the first part of the stroke and more nearly kinetic in the latter part of the intake-valve opening. That is, during the first part of the intake diagram the velocity through the intake manifold is below that corresponding to the depression at the intake-valve port, while during the closing of the valve the airflow, due to inertia, is greater than would be proportional to the depression at the valve port. This inertia or ramming effect should be constant as to the time required for its swing or oscillation from maximum depression to maximum momentum, so that its duration in degrees of crankshaft rotation changes with the engine speed; though it must be initiated more quickly under the more rapid piston-motion of higher speeds. To obtain the best power, we close the intake valve at the time this inertia surge is at a peak, or at least on the rise, and when the piston is rising on the compression stroke; and the greatest volumetric efficiency will be obtained if the valve can be closed at or just beyond the surge peak and when the pressure in the cylinder is at or above atmospheric.

If, however, the forced depression of some other cylinder occurs in the manifold at the time corresponding to the surge pressure-rise of the cylinder we are discussing, the surge peak will not be reached, the energy inducing inward flow will remain in potential form, as depression in the manifold, and the volumetric efficiency and power will be lowered by this interference. Fig. 5 shows the angular time of mutual interference of four, six and eight-cylinder engines with a single carbureter, alternate or interfering suctions being placed on opposite sides of a median line. It will be noted that the interference is little in the case of the four, more with the six and considerable with the eight.

If this surge or ram of the air column occupies a definite duration of time, its effect on the volumetric efficiency will be favorable through a certain range of speed and unfavorable at other speeds above and below. This is borne out by what we find on test; that, in the neighborhood of 2000 r.p.m., the power for a given manifold-vacuum is usually higher with the dual carbureter than the single; but in several instances at 3000 r.p.m. the situation was, if anything, reversed. To move the surge effect up in the speed range would require experimenting with both intake-pipe length and valve timing with the aid of an indicator.

[2] See Air Service Engineering Division Report No. 2608, p. 160.

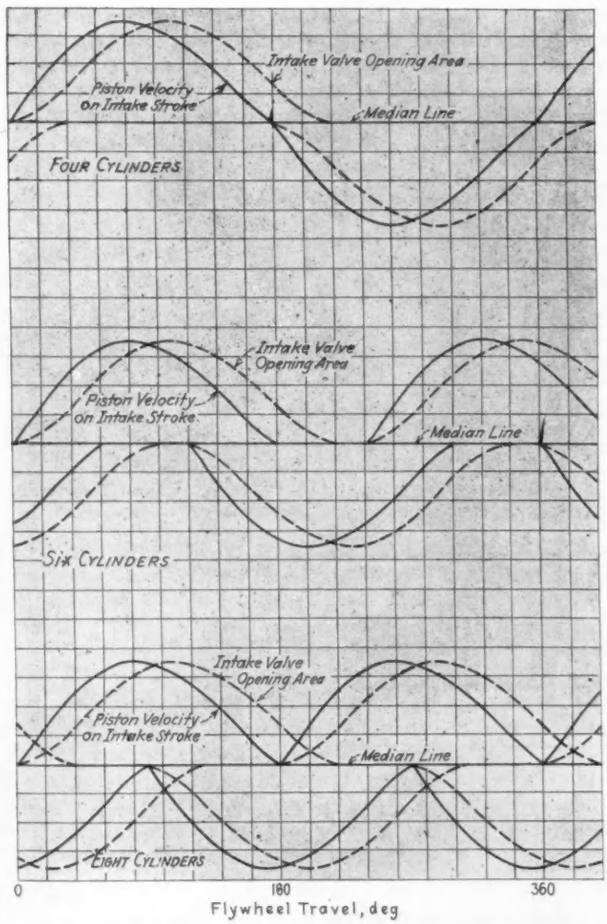


FIG. 5—SUPERPOSED DIAGRAMS OF INTAKE-VALVE OPENING FOR FOUR, SIX AND EIGHT-CYLINDER ENGINES, SHOWING PERIODS OF OVERLAPPING AND INTERFERING SUCTIONS

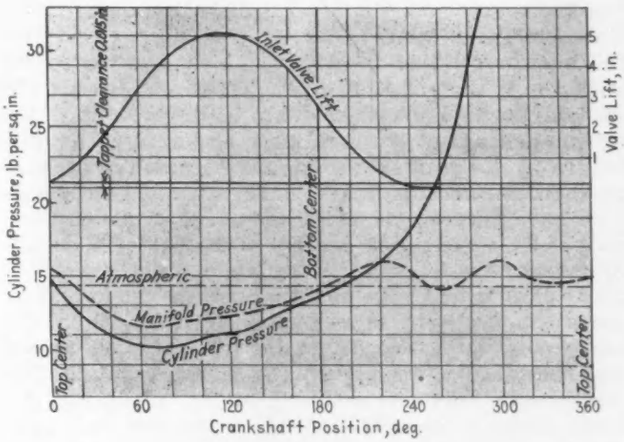


FIG. 6—INDICATOR DIAGRAM SHOWING PULSATION WAVES OF PRESSURE IN THE INTAKE MANIFOLD

Pressure Pulsations and Valve Timing

Pressure pulsations appear on all the indicator diagrams of intake pressures that I have ever seen, but few efforts have been made to analyze them. One careful study of this particular subject is contained in a report by F. Glen Shoemaker, entitled Cylinder and Manifold Pressures During the Induction and Exhaust Strokes. Fig. 6, which is reproduced from this report[2], clearly shows the existence of these pressure waves; it will be noticed that 40 deg. after bottom center the pressure in

the intake manifold reaches 1¾ lb. above atmospheric. These readings were taken with a single carbureter feeding three cylinders equally spaced in firing order. Apparently, the pulsation characteristics of the air column in the intake manifold are superposed upon the pressure change at the valve port, as forced by the piston travel on the intake stroke. The single run here reproduced does not indicate whether the manifold pulsations have the frequency of sound waves, although their periodicity corresponds roughly with that of a closed-end pipe of the length of the intake manifold; nor is it possible to deduce the point at which the manifold pulsations begin to appear as a deviation from the forced-pulsation curve. With the aid of the successful high-speed indicators now available, investigating this phenomenon fully and utilizing to full advantage the intake-stroke energy represented by the peaks of these pulsations should be easy. In the report referred to, a material gain in volumetric efficiency and power is recorded as a result of changing the valve timing of the engine to take full advantage of this inertia effect.

Manifold Arrangement, Shape and Size

We have made some effort to ascertain the sound-pulsation characteristics of different intake-manifolds, by directing a jet of air into them and noting the character and pitch of the resulting reverberation. With a manifold feeding four cylinders, such as the half of an eight-cylinder dual-manifold, a definite pitch is easily noted, which is constant regardless of which cylinder has its intake valve open. With an eight-cylinder single-manifold, or six-cylinder manifolds of either the two-port or three-port type, a definite pitch is less easily found; sometimes two different notes can be distinguished, and the frequency changes considerably as the crankshaft is rotated into different positions. I hope that later we shall be able to find a relation between the natural resonant pitch of an intake manifold and the pulsation waves existing therein; this will, of course, depend on whether the pulsation waves at all times attain the velocity and other characteristics of sound waves. In any case it seems likely that best utilization of this inertia effect to gain power will require symmetrically formed manifolds arranged to avoid overlap of suction strokes.

It has been found, I believe, that suction-stroke interference was considerably worse with a long column of air between the point of junction and the air entrance, as shown in Fig. 7. This indicates that, with a single carbureter on an eight-cylinder engine, the lower manifold at the left of Fig. 8 would give better power than the one directly above, provided the fuel distribution were equally good; I believe this has been found true. This also explains why large free air entrances are necessary to the dual carbureter.

The chief consideration in dual-manifold arrangement is, from the foregoing, to have each carbureter barrel feed an evenly spaced order of non-overlapping suction-strokes; also, this will later be shown to be necessary for smooth idling and light-load operation. With an eight-in-line engine and 2-4-2 crankshaft, this requires one of the arrangements shown at the right, the lower being perhaps preferable on account of the more equal lengths. With a 4-4 crankshaft, something like the arrangement in Fig. 9 will be needed.

The V-eights with 180-deg. crankshaft simply require one barrel to each bank. The V-eight with 90-deg. shaft, however, introduces a more difficult problem. Fig. 10 shows an arrangement that will give even firing but look rather intricate in the V; I believe, however, that the advantages of this arrangement will justify the apparent complication if the details of design can be worked out.

The dual manifold is less sensitive to shape than the single manifold. The reason for this becomes obvious when one watches the flow of water through a model passage of similar shape. Very slight causes, in the entrance of the carbureter or beyond it, are sufficient to throw the stream of mixture slightly to one side. As in Fig. 11 with simultaneous flow from both branches of

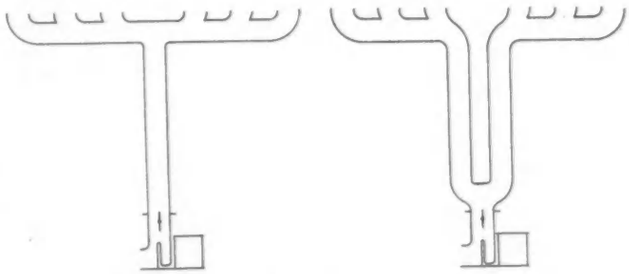


FIG. 7—TWO FORMS OF SIX-CYLINDER MANIFOLD

The Construction at the Left Gives Marked Suction Interference, While That at the Right Was Found To Have Less

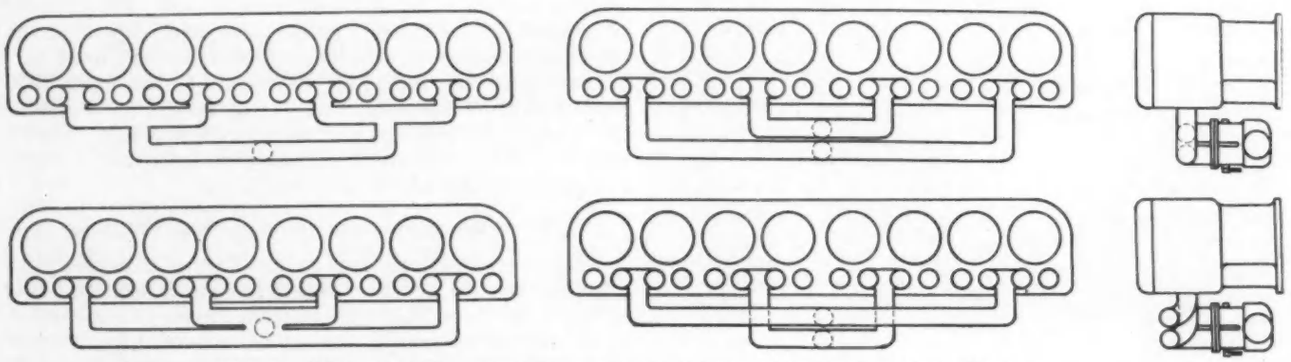


FIG. 8—MANIFOLD ARRANGEMENTS FOR TWO EIGHT-CYLINDER-IN-LINE ENGINES

The Arrangements Shown at the Left Are for a Single Carbureter and the Lower of These Should Give Less Suction Interference and Better Power than the Upper One. The Arrangements at the Right Are the Customary Types for an Engine with a 2-4-2 Crankshaft. The Construction Shown in the Lower View Gives Less Difference in Length and Volume of the Two Manifolds with a Resulting Smaller Difference in Inertia Effect and Idling Vacua

a T, any unevenness of stream-borne content at the entrance gives highly uneven distribution at the outlets; whereas, with flow from only one branch at any one time, an eddy blocks the flow into the other branch, and the distribution becomes a matter of chronology rather than of contour. With the ordinary dual-manifold, the directions of flow do not regularly alternate at the T, but the times of flow barely overlap, and I have seen no dual manifold with marked signs of bad distribution.

The better distributional qualities of the dual manifold make it possible to use velocities lower by far than with any other type of engine with which we have worked. The areas in square inches of manifold passage now in use are approximately 1.20 per cent of the piston displacement in cubic inches as compared with 0.75 per cent for eight-cylinder single-carbureter and 0.65 per cent for six-cylinder single-carbureter manifolds. For some reason, cutting down the area of a dual manifold seems to cut about the same percentage off the power at 2400 r.p.m. as it does at maximum speed, which is seldom true of single-carbureter manifolds.

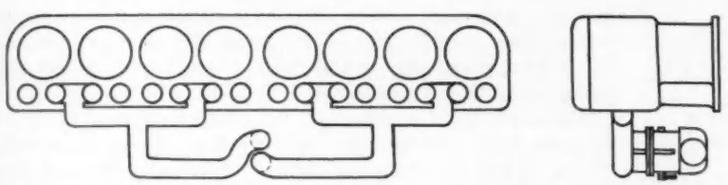


FIG. 9—MANIFOLD FOR AN EIGHT-CYLINDER-IN-LINE ENGINE WITH A DUAL CARBURETER AND A 4-4 CRANKSHAFT

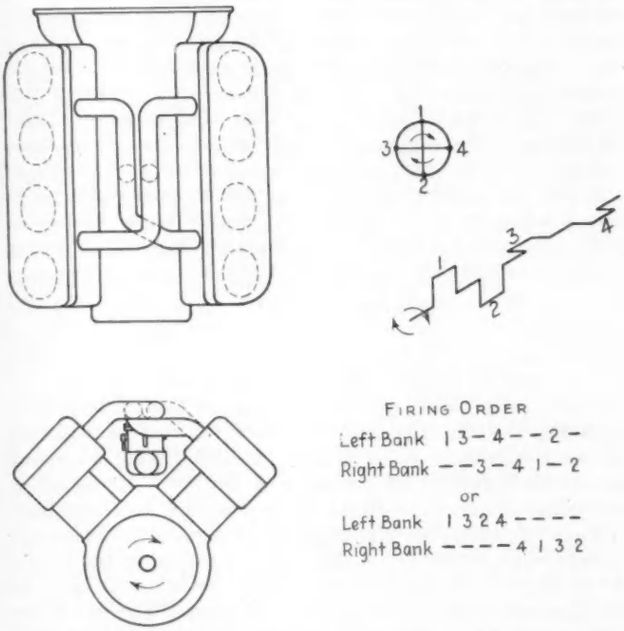


FIG. 10—MANIFOLD ARRANGEMENT AND FIRING ORDER FOR A DUAL CARBURETER ON AN EIGHT-CYLINDER V-ENGINE WITH THE CYLINDER-BLOCK AXES AT 90 DEG. AND A FOUR-THROW 90-DEG. CRANKSHAFT

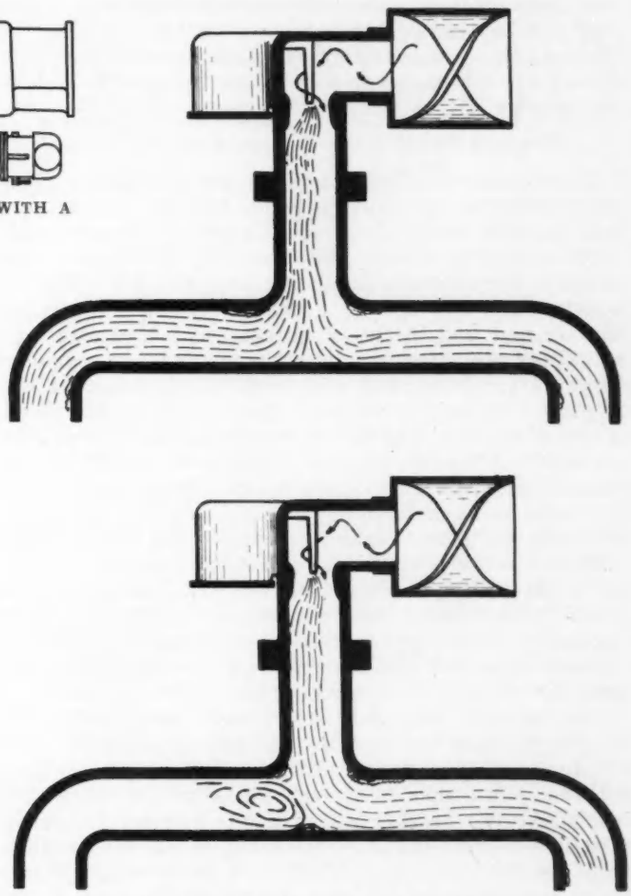


FIG. 11—FUEL FLOW IN TWO DUAL MANIFOLDS

If the Fuel Flow Is Unequally Distributed in the Airstream at the Entrance to the Intake Manifold and Flow Exists Simultaneously through Both Branches, the Inequality Is Continued at the T-Point of Division in the Design Shown in the Lower Drawing. If Flow Exists in But One Branch of the Manifold at Any Given Time, the Conditions of Distribution Are More Favorable, as Shown in the Upper Drawing

Importance of Adequate Mixture-Temperature

In my judgment the different elements of manifold design rank about as follows in importance: (*a*) adequate provision in either cold or warm weather for fairly complete vaporization of the fuel before it reaches the first division point in the manifold passage; (*b*) velocity as high as high-speed considerations will permit; and (*c*) a little common sense as regards the contour of the passages. This opinion is based on the following observations:

(1) I have seen no form of manifold that would enable an engine to run satisfactorily on definitely wet mixtures at average intake-manifold air-velocities below 37 ft. per sec.

(2) Some engines that can scarcely be made to run without heat at manifold velocities around 100 ft. per sec., figured on a basis of 75-per cent volumetric efficiency, seem to have almost perfect charge-distribution above a mixture temperature of 130 deg. fahr.

(3) Such engines as I have seen that could fire smoothly when cold at high intake-velocities did not show, in a car, more power or pickup at these speeds than after they had warmed up enough to pull steadily at low speeds.

(4) Under conditions of reasonably complete vaporization and mixing between the carbureter and division point of the manifold, indicated in

practice by the ability to pull at low velocities without "loading," the contour of the manifold has not seemed to matter very much, and a number of different shapes have been equally satisfactory. In actual use of a car, of course, to have the engine run as well as possible during the warming-up period is desirable; but the best selection I have seen of contour and firing order is still entirely dependent upon mixture temperature as to its satisfactory operation.

These observations point to the conclusion that the *chief* consideration in a passenger-car intake-system is the maintenance of the mixture temperature between practical limits of, say, 120 and 160 deg. fahr. This may not be true of other types of engine service, for instance those of continuous load at a fixed fairly high speed; but I have never seen an engine operate well in any service with a "stone cold" intake manifold.

Reasons for Mixture-Temperature Variation

Maintenance of efficient mixture-temperature is largely a matter of the ability to apply heat in varying rate and quantity under different atmospheric temperatures. With any given design and dimension of hot-spot, the mixture temperature is almost constant for different steady loads and speeds, provided the temperature of the air and fuel in the carbureter do not change. In actual car operation, however, the air and fuel temperatures vary widely, and with fixed hot-spot action the mixture temperature follows. This is better understood if one appreciates the nature and conditions of the heat transfer. A thin metal plate exposed on one side to the flame of a blowtorch will not rise to a high temperature if a small spray of liquid is discharged against the other side; the high heat-capacity of the liquid and its intimate contact with the metal will carry heat out as fast as it can be transmitted into the plate from the hot gases of the flame. Similar conditions exist in the heating wall of a hot-spot, so that its temperature varies in opposite direction, and through a wide range, with the quantity of liquid fuel striking the wall.

Assume that a manifold of the type shown in Fig. 12 is used on a cold day with air and fuel entering the carbureter at 40 deg. fahr. Approximately 8 per cent of the fuel will evaporate at the jet, and the remainder will strike the heating walls; if the exhaust temperature be 900 deg. fahr., the wall temperature will be perhaps 120 deg., and the fuel will flow along it at slightly below this temperature, evaporating at its surface as the airstream "scrubs" it. The final mixture will be low in temperature and decidedly wet.

Next assume a spring day, with air and fuel entering the carbureter at 100 deg. fahr.; 40 per cent of the fuel may evaporate in the carbureter, and the remainder may cool the hot-spot wall to about 380 deg.; the liquid fuel on the walls will be much less in quantity than before, and probably it will evaporate before leaving the manifold, reaching the cylinders as a thin fog at a temperature between 130 and 150 deg. fahr.

Finally, assume entering air and fuel temperatures of 150 deg. fahr., which I have actually observed on a hot summer day. Under these conditions the fuel has probably disappeared into vapor 6 in. beyond the jet, and no liquid is on the hot-spot walls, the temperature of which may now rise above 600 deg. fahr., hot enough to discolor brass and to char any but asbestos gaskets. The radiation effect from the walls will be considerable at this temperature, and the mixture temperature at the cylinder port may reach 200 deg. fahr.

Perhaps it is worthwhile to interrupt here to point out the very considerable change that these conditions make in the accelerating charge required from the carbureter. In the first instance, any increased rate of mixture delivery at the carbureter will give an immediate increase of air at the cylinder ports, but several seconds might elapse before the corresponding fuel delivery could arrive at these same ports; and unless the mixture proportion at the carbureter were temporarily enriched, the engine probably would be unable to fire just after the throttle is opened from the idling position. In the case of summer operation, any change in mixture delivery at the carbureter will instantly carry up air and fuel in equal proportions to the cylinder port; and any temporary extra fuel-feed, as needed to avoid too lean a mixture in the cylinder port in the first instance, would give a mixture temporarily too rich to fire.

"Heat-Flywheel" Effect

Even greater extremes of temperature are experienced, due to what may perhaps be graphically described as a "heat-flywheel" effect. The actual temperature-distribution during steady high-speed running in the common form of intake manifold may be about as shown in the upper drawing of Fig. 13. Upon starting, some time is required to reach this temperature; and upon stopping, or even upon the diminution of liquid feed against the walls following closing the throttle to the idling position, the temperature will tend to equalize throughout the metal of the manifold as in the lower drawing, resulting in an unusually high temperature on the intake-manifold walls. I have seen iron and steel discolored in this way. Upon starting or opening the throttle soon afterward, an augmented heating-

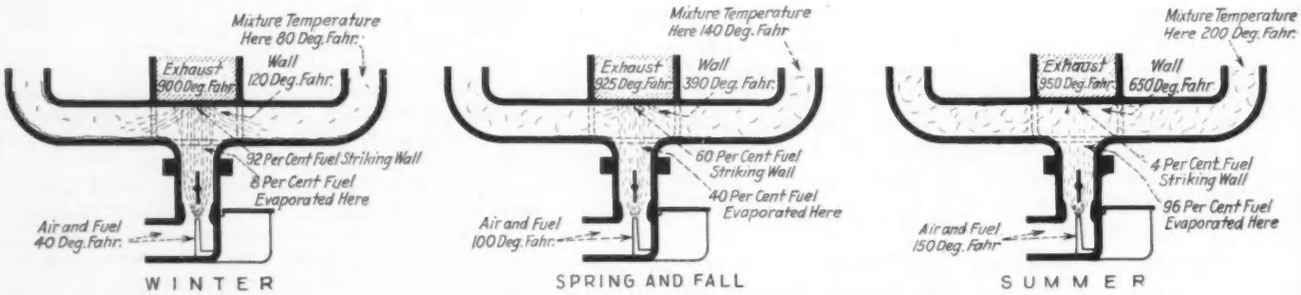

Mixture Temperature Here 80 Deg. Fahr.
Exhaust 900 Deg. Fahr.
Wall 120 Deg. Fahr.
92 Per Cent Fuel Striking Wall
8 Per Cent Fuel Evaporated Here
Air and Fuel 40 Deg. Fahr.
WINTER
Mixture Temperature Here 140 Deg. Fahr.
Exhaust 925 Deg. Fahr.
Wall 390 Deg. Fahr.
60 Per Cent Fuel Striking Wall
40 Per Cent Fuel Evaporated Here
Air and Fuel 100 Deg. Fahr.
SPRING AND FALL
Mixture Temperature Here 200 Deg. Fahr.
Exhaust 950 Deg. Fahr.
Wall 650 Deg. Fahr.
4 Per Cent Fuel Striking Wall
96 Per Cent Fuel Evaporated Here
Air and Fuel 150 Deg. Fahr.
SUMMER

FIG. 12—DIFFERING AIR AND FUEL TEMPERATURES AT THE CARBURETER CAUSE A TEMPERATURE VARIATION IN THE INTAKE MANIFOLD

effect will be experienced, the magnitude and duration of which will be proportional to the manifold mass, and specific heat, in relation to the piston displacement. That the time of warming up, and the heating of the intake after slowing down, will be much greater with a manifold of exaggerated wall mass, is apparent.

Means of Heat Control

Doubling the number of intake manifolds on an engine, as in the dual system, is unfavorable in the way described, both because of the greater mass of the casting and the greater sectional area available for heat conduction. Engines of different make vary greatly in this respect according to their design; but with intake and exhaust manifolds cast in one piece, the residual-heat effects, loss of power, decreased speed, fuel boiling in carbureter, and sensitiveness to too much accelerating charge are definitely more marked in the engine with dual manifolds than in one with a single-intake system.

The most effective steps in dealing with this problem seem to be (*a*) to make the exhaust manifold, including the heat-control valve, in a casting separate from that of the intake; (*b*) to use a gasket spacer with effective heat-insulating qualities between the two; (*c*) to use aluminum for the intake manifold; (*d*) to design the heat jacket of the intake casting with more surface exposed to the exhaust than is now common practice, taking care that ribs or boundary surfaces are disposed to conduct to the inner or charge-heating wall the heat picked up from the exhaust by the outer wall of the jacket; and, (*e*) most important, to design the passages and control valve so that all the exhaust can circulate through the jacket during the warming-up period in cold weather, that part of the exhaust can be utilized for steady running in cold weather, and that virtually all exhaust circulation can be cut-off on a hot summer day. These changes should be easily made by a control on the dash; in any position of the control the exhaust passages should be large enough not to restrict the power by back-pressure.

The chief need of full exhaust-circulation through the heater is for warming up, so as to overcome the heat inertia of the manifolds; and it is remarkable how little heat application need be used once the manifolds are warm. Considerable heat is necessary for city driving in spring and fall, so that intermediate positions of the heat-control valve are necessary.

In a few years a construction may be devised whereby the temperature of the air and fuel in the carbureter, and of the carbureter itself, can be held at about 100 deg. fahr. This would obviate the need of hot-spot and accelerating-charge adjustments, and also eliminate the trouble of boiling gasoline in the carbureter.

In the eight-cylinder dual system, when the manifold feeding cylinders Nos. 3, 4, 5 and 6 is made short and next the cylinder-block, as in the arrangement shown at the upper right of Fig. 8, it usually carries a higher mixture-temperature than the other manifold by reason of the shorter distance and greater mass of metal for heat conduction; but apparently the longer passage to cylinders Nos. 1, 2, 7 and 8 has better distribution, or better heating of the charge before it reaches the valve ports, because, after starting, in two engines I have observed, normal firing was attained in these cylinders some time before those fed by the shorter manifold. One attempt to bring the mixture temperature of the short branch down to that of the long one did not give satisfactory operation.

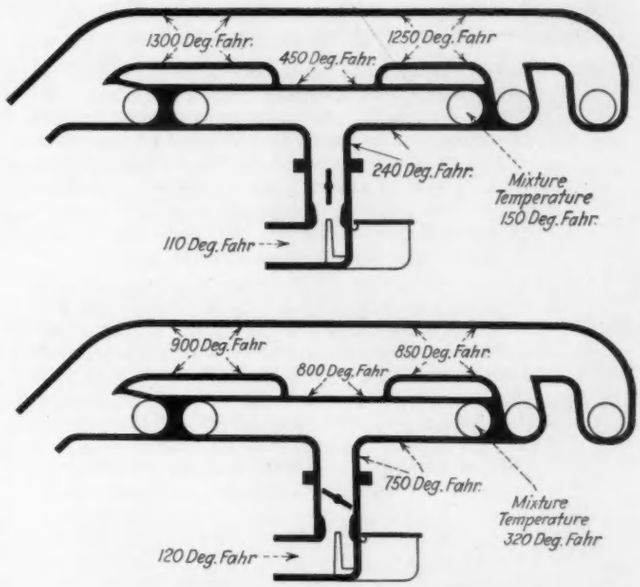


FIG. 13—"HEAT-FLYWHEEL" EFFECT

The Upper View Shows the Distribution of Temperatures in the Manifold Wall During Steady High-Speed Running across Country. The Lower View Shows the Temperatures in the Same System a Few Minutes After Speed Was Reduced

Idling and Light-Load Performance

Ever since the introduction of the eight-cylinder engine, its idling has been subject to criticism. I do not mean that the fours and sixes, as classes, idled satisfactorily; as a matter of fact, our demonstrating engineers probably spend as much time on all engines trying to lower the speed of safe idling, to overcome stalling and to eliminate misfiring and an evil smell from the exhaust while the car or the motorcoach is coasting down from high speed with clutch engaged and throttle closed, as they do on any other phase of engine operation. Furthermore, they spend this time unprofitably, because the fault seldom lies in the carbureter, which, though popularly supposed to control entirely the ability of an engine to idle, actually can do no more than supply a mixture of any desired strength.

A low idling-speed is more important in sales demonstrations than in average service; few drivers will complain of a positive non-stalling road idling-speed of 6 m.p.h. More serious is the fact that, with increasing proportion of reserve torque, acceleration and hill-climbing ability, each year our engines approach more nearly an idling condition as they travel along at legal city-driving speeds. In particular, the fuel economy suffers. Yet, so far as I know, no systematic research has been made regarding the factors that govern the ability to fire smoothly and on thin mixtures at light loads; no authoritative articles on this subject are to be found in the journals of the different automobile engineering societies; and so little is known of the requirements of light-load efficiency that they are seldom considered in designing an engine.

In our own organization we have for some time had a program of research before us on this subject, but more urgent matters have continually taken prece-

dence. It may be of service, however, to state the two main phases of the problem as we see them.

(1) To fire regularly at light load and on attenuated air-charges, the average engine seems to demand increasing richness of mixture as the manifold vacuum increases above 14 in. of mercury; at about 18 to 20 in. the firing becomes uncertain with any mixture strength; and above 21 in. the engine scarcely fires at all. Conditions are worse at the low idling-speeds, in that it is harder to avoid an occasional miss.

(2) Applying to idling only is the tendency toward variation of the engine speed. When an attempt is made to lower the idling speed of an engine, a point is reached at which the rate of angular rotation begins to oscillate or "roll," as this is commonly called; if the roll augments, the engine will soon stop in one of the phases of slow travel. Sometimes an engine will not idle on account of definite missing, regular or intermittent, but more often the minimum speed of safe idling is that just above the rolling point. If we could reduce this tendency to roll, as by a heavier flywheel, or keep the conditions of firing stable, so as to dampen out the roll once it starts, a lower steadier idling-speed would result.

Idling Stability

Considering the latter phase first, for reasons of convenience, it is necessary to understand the relation, or rather lack of relation, between airflow and engine speed at the high manifold-vacua attending idling. When a gas at pressure P_1 flows through an orifice into a region of lower pressure P_2, the rate of flow is greater as the pressure P_2 is lowered, until a certain limiting velocity is reached, which is the velocity of sound in the gas at the condition P_1. For air at sea-level pressure flowing into the intake manifold through the throttle orifice, this limiting velocity is reached at a manifold vacuum of about 14.4 in. of mercury. This means that, at vacua greater than this, engines usually idle at vacua over 16 in., the airflow, and with most types of carbureter the fuel flow, past the throttle into the engine are constant per unit of time, independent of engine speed, and *the quantity of charge per cylinder is directly inverse to the engine speed.* This has several results worth studying. These are

(1) If the throttle stop-screw of an engine is set to give an idle of 5 m.p.h. and, while driving 50 m.p.h. the throttle be allowed to return to the same closed position, the mixture charge *per cylinder* at 50 m.p.h. will be one-tenth the weight of the 5-mile idling charge and entirely too weak to fire. The unburned mixture passing through the hot cylinder develops a pungent disagreeable smell that is annoying when it enters the car or motorcoach body. As the vehicle slows down, the charge per cylinder will increase in strength, reaching a richness at which occasional ignition will occur, but the rate of flame propagation will be so slow that burning will exist when the exhaust valve opens. Under certain conditions the unburned gas reaches an ignitible strength in the muffler, may ignite from the delayed-burning exhaust of some cylinder that has ignited and give a muffler explosion. As the vehicle slows down still more, a charge density is reached at which ignition will generally occur but will not be entirely regular; if this condition is marked, the universal-joints and other loose places in the drive will "chuckle" until firing becomes regular. About all we have been able to do so far in the way of cure is to make firing conditions as uniform as possible in the cylinders, so that they all come in at once when they do start to fire. Careful adjustments of the mixture and spark-advance help a little, and usually a certain throttle opening is better than either a faster or slower idling-opening. Enough trouble has been experienced from this source to warrant a thorough investigation, but I do not know that anyone has found time for one.

(2) Another result of this idling-feed constancy per unit of time is that *the charge per cylinder varies if the time between suction strokes is irregular.* Instances of this sort are (See Fig. 14) a twin V-type motorcycle-engine having both connecting-rods on the same crankpin; an eight-cylinder V-engine with four crankshaft throws at 90 deg. and one carbureter barrel feeding each bank; and the experiment sometimes tried of putting three carbureters, or at least three throttles, on successive pairs of cylinders of a six-cylinder engine having the standard form of crankshaft. In any of these instances, flow of mixture past the idling throttle-opening will go on whether an intake valve is open or not, and the cylinder whose intake valve opens after the long interval will receive a definitely stronger charge than one drawing after a short interval.

(3) Lastly, this constant flow furnishes the explanation of the tendency of an idling engine to roll. If for any reason one cylinder fails to fire with average strength, the flywheel will slow down a little, and the cylinder at that time drawing will receive a greater-than-normal idling-charge, which will then tend to increase the angular speed of the flywheel to above that of normal idle; if it does so increase, the next cylinder will receive less than the regular idling-charge, the flywheel will slow down again, and so on. Whether the roll dampens out or increases seems to depend upon the relation of the flywheel moment of inertia to the friction drag of the engine, which in turn is equal to the idling indicated torque, and upon the uniformity of firing of the cylinders. During the slowing-down phase of the oscillation, certain essential parts of the engine operation, such as the spark break or valve openings, may get "out of time," which would definitely account for the engine dying on the slow phase of the roll. Why a slight increase of flywheel moment of inertia is so often effective in improving the idle is easily understandable.

Irregular Miss When Idling

Even though the roll be overcome, we encounter many instances in which engines show a definite irregular miss on idle, and this tendency usually carries up into the level-road driving-range. Sometimes we have found the cause of the trouble and its cure, sometimes it has disappeared during our work without our knowing just which step was responsible, and sometimes we have found no remedy. The chief known cause is disturbance of the normal process of fuel and air proportioning through the carbureter, by manifold or valve-guide air-leaks, intake or exhaust valves not seating tightly, or

non-uniform overlap of exhaust and intake-valve openings in the different cylinders (See Fig. 15). Inadequate mixture-temperature would account for irregular firing, but in our observation the mixture is usually dry under sustained idling, even though wet at full throttle. Different forms of equalizer duct have been used on eight-cylinder engines, but after long trial I could not see that they did any good, except in the case of a V-engine with 90-deg. cranks, where they were necessary, to compensate for uneven suction-intervals.

Work on the ignition system has often improved the idle. The beneficial effect of widening the spark-plug gaps is well known. This is effective even though no spark is being induced at some plug, which is out of time, through proximity of the high-tension paths. Producing a spark longer either in path or in duration seems likely to make ignition more certain. I have witnessed no positive demonstration that changing the shape of the cylinder-head or the location of the spark-plug made a definite improvement in the light-load operation, although this has often been reported.

Some engines we have had idled well, others would not idle at all steadily, at 5 m.p.h. In no case did the substitution of a single-carbureter system for the dual or vice versa, on the same identical engine, affect appreciably the idling performance.

Fuel Consumption at Light Loads

This tendency toward irregularity of firing has extended up into the legal city-driving speeds, where it can often be cured by the use of a slightly rich mixture. The dual system seems in this respect a little more sensitive than the single system on some engines, possibly because of the lower intake-velocities. Another

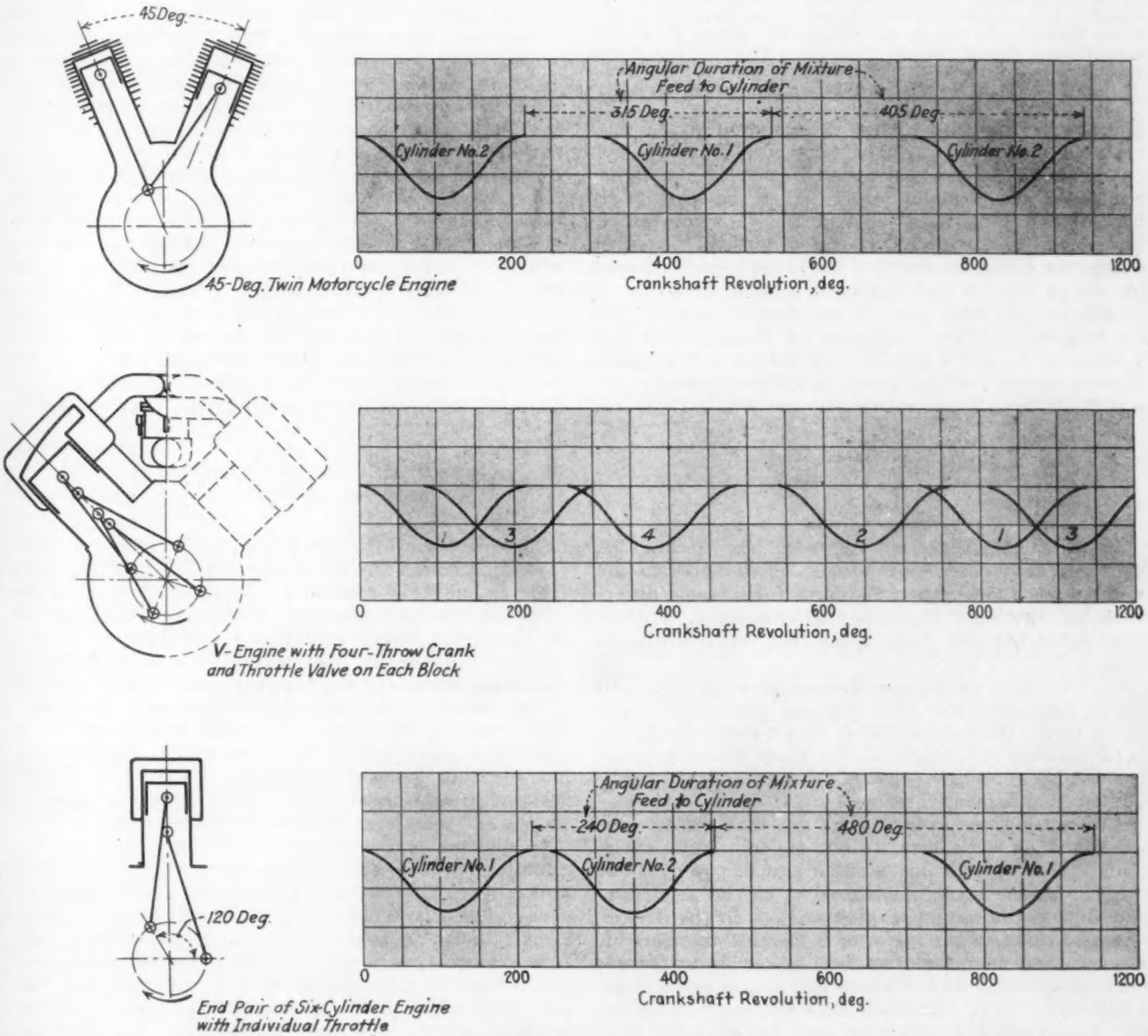


FIG. 14—DIAGRAMS SHOWING HOW IRREGULAR SPACING OF SUCTION STROKES RESULTS IN UNEQUAL STRENGTHS OF AIR AND FUEL CHARGES

During Light-Load Running the Flow of Mixture Past the Partly Closed Throttle-Valve into the Vacuum of the Intake Manifold Continues After an Intake Valve Is Closed, and the Quantity of Charge Received per Cylinder Is Greater After the Longer Interval

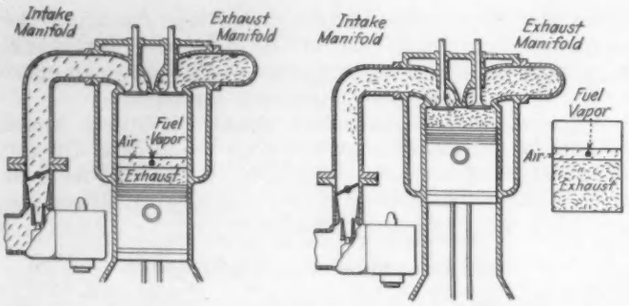


FIG. 15—COMPARISON OF THE CONTENTS OF THE CYLINDER UNDER DIFFERENT CONDITIONS OF OPERATION

The View at the Left Shows Conditions at the Beginning of the Compression Stroke under Normal Idling-Conditions. The Larger View at the Right Shows Conditions in the Cylinder at Light Load When the Closing of the Exhaust Valve Overlaps the Opening of the Intake Valve. With Atmospheric Pressure in the Exhaust Manifold and an 8-Lb. Vacuum in the Intake Manifold, a Very Slight Simultaneous Lift of the Exhaust and Intake Valves Will Permit Cross Flow as Shown. The Small View at the Extreme Right Shows the Resulting Proportions of Air, Gasoline Vapor and Exhaust in the Cylinder When Compression Begins

difficulty with regard to fuel consumption on the dual system comes from its increased tendency to detonate, on the same compression-ratio, because of its higher compression and greater power. When the spark is set back to cure this, we often find that it is too far retarded for best economy at closed throttle. In other words, the difference between the proper spark-advance for closed throttle and for open throttle seems to be greater on the dual than on the single system. Also, the peculiarity in the torque curves illustrated in Fig. 3 seems to develop a special requirement in the spark-advance needed for best power at different speeds, that is difficult to fulfill by automatic means. I trust our ignition engineers will correct me if I am not right.

Carburetion problems are in general easier of solution with a dual carbureter and manifold on an eight-cylinder engine than with a single carbureter on either an eight or a six. As previously stated, we can use larger areas and lower velocities. Fewer departures from a uniform mixture-proportion are required, enrichment at light loads and for idling being the only pronounced essential. Almost no accelerating charge is required; in fact, the sensitiveness to too much accelerating charge is perhaps the most outstanding characteristic. The warming-up period is short and taken care of without much enrichment of the mixture.

One structural difficulty is the need of exact fitting of the throttle valves for idling. Instructing the service men how to handle twin idle adjustments, though this is not difficult, has taken a little time. We have had some difficulty overcoming a tendency to "load" when pulling at full-load wide-open throttle at very low speeds, say below 8 m.p.h. This is perhaps explained by the very low intake-velocities used and is not of much importance in the actual use of a car. No such tendency was experienced on one engine which had the heat jacket on the manifold brought right down to the carbureter flange; with such a construction, however, a control must be provided to cut off nearly all the exhaust heating in summer, otherwise much trouble will be experienced from fuel boiling in the carbureter.

Altogether, the dual manifold and carbureter seem necessary to the full development of the superior qualities of the eight-cylinder engine. I have seen good carburetion and low power with the single-carbureter system, also less satisfactory carburetion and high power; but never as good all-round performance, judged by the standards of either the engineer or the ordinary motorist, as is easily obtained with the dual system.

THE DISCUSSION

CLAUDE S. KEGERREIS[3]:—Our work has checked Mr. Mock's eight-cylinder observations and we agree mainly in the six-cylinder work. We have found some differences but these are too minor to enumerate. I absolutely agree with Mr. Mock in the four requirements he listed.

We are building air-cleaners, because we want to protect the carbureter metering and power. We have found, in our development work on air-cleaners, that if we have a high resistance, or even a low resistance with considerable spiralling through the cleaner, the results suffered. Consequently, we took great pains in the design of our cleaner to straighten out that airflow and have found, on block tests, a slight supercharging effect at high-torque points instead of a loss in power. It is nothing but the straightening effect in the airstream coupled with the minimum pressure-loss in the device.

Several times in the last 6 or 8 months engineers of designers and manufacturers have asked us to recommend intake-manifold temperatures. I have given them as 120 to 155 deg. Mr. Mock says that he goes up to 160. Apparently the carbureter men are agreeing.

F. G. SHOEMAKER[4]:—The tests that Mr. Mock mentioned in regard to intake-manifold pressures were made in 1922 at McCook Field on a Packard 1237 aircraft engine. The diagrams were made with a Bureau of Standards balanced-pressure diaphragm-indicator of an early type. Each card took about 45 min. of continuous full-throttle operation, the results being a panoramic picture of the conditions in this period. Due to the location of the pressure connections in the manifolds, the observed pressures are the resultant of both static and impact effects which cannot be separated and hence cannot be used for precise calculations. However, when considered only as fairly accurate pictures, they reveal some very interesting characteristics.

In contrast to the reports about not obtaining this ramming effect on six-cylinder automobiles, it has been shown repeatedly on aircraft engines that a gain in power of at least 5 per cent is obtainable by going from a six-cylinder to a three-cylinder manifold grouping. It is obvious from a study of the pressure cards mentioned that the valve timing must be different with the two types of manifold to take full advantage of the ramming effect. This may account for the negative results obtained on some six and eight-cylinder automobile engines.

I should like to emphasize the importance of knowing the actual instantaneous pressures in the manifold and

[3] M.S.A.E.—Chief engineer, Tillotson Mfg. Co., Toledo.

[4] M.S.A.E.—Research engineer, powerplant section, General Motors Corp. Research Laboratories, Detroit.

cylinder before any intelligent improvements can be made in valve timing and manifold arrangement. The customary cut-and-try method is particularly hopeless in this case on account of the great number of factors that can be varied without being able to evaluate the effects of each change. The number of experimental camshafts in the engine laboratories is ample proof of this point. The electrical indicators now being developed should make such pressure studies entirely feasible, and a basic study along these lines would be of great benefit to the industry, particularly in the design of camshafts and manifolds.

Diagrams of Blowback and Ramming

H. M. JACKLIN[5]:—Mr. Mock's remarks about blowback through the carbureter and about ramming effects have caused me to think that the members might be interested in some indicator diagrams taken to show these effects. These diagrams were taken with a 20-lb. spring, as indicated alongside the upper diagram in Fig. 16, on cylinder No. 6 of a six-cylinder engine operating with full throttle at 500, 1000 and 2000 r.p.m. The small loops at the end of the inlet or suction stroke and the beginning of the compression before the inlet valve closed at about 35 to 40 deg. were very clear in the original diagrams and have lost little in tracing, while the ramming effect, totalling 3 lb. per sq. in., is very clear at the higher speed. This blowback, or more accurately this drawback, was not at all apparent at the carbureter inlet, as it would extend only to the laterals of the manifold and be absorbed or cured by the succeeding cylinder. With a dual manifold this blowback would probably be very apparent at low speed, since no overlapping of suction strokes in each bank of three cylinders would occur. The remedy for the fuel losses because of such blowback would be to use a fairly long inlet-horn on the carbureter. If this blowback were eliminated by a change in inlet-valve closing, the engine would certainly suffer at the higher speeds. Therefore, we must compromise in the valve timing as well as in other things.

The exhaust-valve timing and the manifolding seem to be especially well chosen in this particular engine, as the exhaust gases actually help the engine at 500 r.p.m. At 1000 r.p.m. the exhaust pressure drops to the atmospheric line and does not rise until near the end when the exhaust valve is closing. At 2000 r.p.m. the exhaust back-pressure does not appear excessive at any time. The high velocity induced in the inlet manifold results in some ramming at all three speeds, but the inertia of the mixture column is not great enough to prevent blowback at the two lower speeds. This inertia actually results in a pressure increase of 3 lb. above atmospheric at the start of compression at 2000 r.p.m.

In some tests on an eight-cylinder engine, with a dual manifold and using a 2-4-2 crankshaft, I have found that the ramming effect on cylinders Nos. 1, 2, 7 and 8 is between 1½ and 2 lb. higher than that for the center four cylinders. This is due entirely to the longer

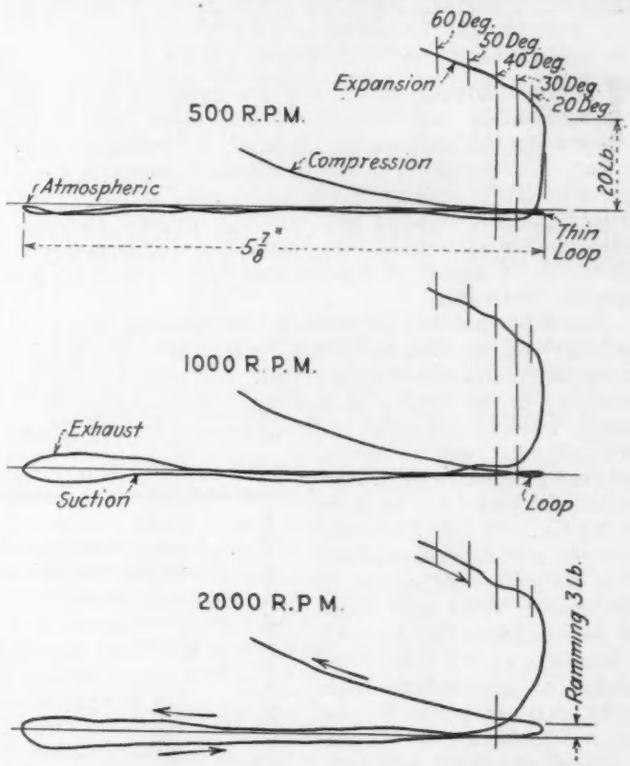


FIG. 16—INDICATOR DIAGRAMS TAKEN TO SHOW BLOWBACK THROUGH THE CARBURETER AND RAMMING EFFECTS

These Diagrams Were Taken with a 20-Lb. Spring on Cylinder No. 6 of a Six-Cylinder Engine Operating with Full Throttle at 500, 1000 and 2000 R.P.M. The Increase in the Back-Pressure and the Early Suction-Pressure Lines with Increased Speed Should Be Noted as Well as the Blowback Loops at the End of the Inlet and Early Compression Lines at the Lower Speeds and the Ramming Effect at the Higher Speed

laterals to the outer cylinders, which gives a greater mass of air-fuel mixture acting to cause such ramming.

I must also point out the greatly increased "pumping losses" at higher speeds as indicated in these diagrams by the increasing area of the diagram between the exhaust and suction lines with increased speed. This area is a direct measure of the work done in removing the exhaust gases and drawing in a new charge.

[5] M.S.A.E.—Associate professor of automotive engineering, Purdue University, West Lafayette, Ind.

Better Chassis Lubricant

By C. W. SPICER[1]

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS

IN the following discussion, the question of chassis lubrication will be approached from the user's standpoint rather than that of the lubricant producer. Furthermore, it will be confined mainly to those parts of the chassis to which high-pressure fittings are now commonly applied and will not include the rear axle, transmission-gear case, engine, or electrical equipment, all of which in general require selected, if not special, lubricants.

The following bit of history will possibly serve as sufficient explanation as to why a parts specialist should presume to discuss a subject that concerns the entire chassis. In the production and application of universal-joints, I discovered early in my experience that the market afforded not a single lubricant that was really satisfactory for use in such joints. This discovery aroused my interest, and led to a rather careful study of the subject from that time, 18 years ago, to the present.

Perhaps no other material used in connection with motor-cars is shrouded in so much mystery to the average engineer and layman as lubricants and the subject of lubrication. Furthermore, I doubt if any other engineering material has been juggled by the chemist and shrouded with mystery by the salesman to the extent that petroleum products have been and to a great extent still are. Buying lubricants should be no more mysterious than buying a suit of clothes. The cloth in the clothes unquestionably will be a mixture of certain standard materials, various combinations of which give the desired results for various purposes. The wool, cotton and other materials used in fabrics, however, vary to a very great extent in quality and length of fiber. In much the same way a wide variation exists in the quality of the different substances used in lubricants. The general and particular characteristics depend both on the source of the original petroleum supply and on the methods and skill that have been used in its refinement.

Virtually all fluid lubricants are blends of two or more fairly well-standardized grades of petroleum products, the grades and blends being selected in such a way that the resulting blend will have the required characteristics as a lubricant for the purpose intended. The semi-fluid and non-fluid lubricants may, in general, be placed in one classification; they are in most cases mechanical mixtures of soap and lubricating oil. The physical nature of the mechanical mixture is not definitely understood. Some authorities consider the mixture as more or less colloidal; others, that the soap forms a kind of honeycomb structure for the retention of the oil. This is an interesting analogy, at least with those lubricants that tend to become thinner or apparently break down by mechanical agitation, as would be the case in the gearbox or universal-joints.

This paper will be confined to the conception that the lubricant is a mechanical mixture and not a chemical combination. The purpose of the soap in the lubricant is therefore merely to act as a sponge or carrier for the lubricating oil and to give the oil a form in which it can be most readily applied to the bearings. In general, the soap serves little or no other useful purpose. Since for most purposes soap is less valuable as a lubricant than the oil it displaces in the mixture, it may be considered desirable that the compound shall contain no higher percentage of soap than is necessary to obtain the desired physical characteristics of the lubricant. Also, we should remind ourselves of the well-known fact that various grades of oil exhibit varying grades of resistance to bearing pressures; so we may say with approximate accuracy that, the higher the viscosity of the oil is, the greater will be the bearing pressures it will sustain. This statement assumes the fundamental conception that the purpose of the lubricant is to maintain a clearance between the bearing surfaces so that little or no actual metal-to-metal contact shall occur.

Lubricants and lubrication are shrouded in more mystery than any other material and subject connected with motor-cars.

All fluid lubricants are blends of two or more fairly well-standardized grades of petroleum products, while the semi-fluid and non-fluid lubricants are generally mechanical mixtures of soap and lubricating oil, the former serving as a carrier for the latter.

The mechanical mixture is separated in the universal-joints by the action of centrifugal force due to the difference in the specific gravities of its constituents.

In contrast to all the radical improvements made in motor-cars in the last 20 years, lubricants for general chassis use are substantially the same except for minor refinements in production methods.

This situation can be overcome, at no great increase in cost, by the use of higher-viscosity oils, and progress will be made if the automotive engineer will demand and standardize a better chassis lubricant.

[1] M.S.A.E.—Vice-president and chief engineer, Spicer Mfg. Corp., South Plainfield, N. J.

Since virtually all semi-fluid and non-fluid lubricants suitable for motor-car use are only mechanical mixtures, the soap and oil, if of different specific gravities, may be and often are readily separated in universal-joints and the mixture broken down by centrifugal action.

Soap for the purposes under discussion may be made by mixing, under proper conditions of temperature and moisture, any one or several well known alkalis with a saponifiable oil. Most of the soaps used in motor-car lubricants are the result of using sodium, potassium or calcium hydroxide. Most of the ordinary yellow cup-greases having a smooth non-fibrous texture are so-called lime-greases, the soap content being a product of some saponifiable oil with calcium hydroxide.

I have never seen a straight lime-grease that would withstand the centrifugal action in universal-joints at speeds that are now common in motor-cars. Up to the present nearly all of the greases that have been developed as satisfactory for universal-joints have contained a soda-base soap. In a few instances greases that were satisfactory in operation have contained small percentages of lime or potash in combination with the soda.

Trend Toward Better Lubricants

A very large majority of the service and filling stations throughout the Country are still dispensing some form of the ordinary yellow lime cup-greases. I say "still" because a very definite undercurrent toward better lubricants is apparent at present. In fairness to all concerned, and in view of what I shall say later, let us admit that the yellow lime cup-greases have or had these advantages:

(1) The low-viscosity oil from which they are usually made was, at the time these greases established themselves on the market many years ago, lower in cost per gallon than the higher-viscosity oils. Furthermore, calcium hydroxide was a very cheap alkali for the production of soap content.

(2) The low-viscosity oil is less affected by the usual temperature-range than the high-viscosity oil, and, since the comparatively high soap-content is still less affected by temperature, the lime grease of low-viscosity oil is more easily used over a wide temperature-range than if a higher-viscosity oil was used.

(3) With similar oil viscosity and percentage, the lime greases do not emulsify with water as readily as do the soda and potash greases, and therefore, theoretically, are not so easily washed out of the bearings if a large quantity of water is present.

Considering the foregoing present or past advantages seriatim,

(1) Present costs are very different than they were at the time the lime greases established themselves on the market, so that now, quantity for quantity, and quality for quality, a first-class soda-grease containing a small percentage of soap and mixed with oil of high viscosity can be produced at very little if any advance over the cost of the lime greases. However, only a few of the oil companies are actually in large-quantity production on the soda high-viscosity greases.

(2) With the usual method of application, the range of temperature of those parts of the motor-car chassis that are commonly equipped with so-called high-pressure fittings is not sufficient, in average motor-car service, to make much difference as to the kind of oil used to make the grease, except that somewhat more powerful pumps may, in some instances, be required for the soda greases made from high-viscosity oil. Sufficiently powerful dispensing equipment is now available in both large and small sizes at reasonable cost.

(3) In most instances, a good low-soap-content high-viscosity oil-soda grease will stay in the bearings better under adverse conditions than will the usual type of high-soap-content low-viscosity oil-lime greases because of the greater cohesion of the high-viscosity oil and also because the lesser proportion of soap tends to offset the difference in emulsiveness.

What the Manufacturers Are Doing

With these facts in mind, I addressed letters to the technical departments of five large and well-known oil companies operating in the Eastern and Central States asking each company, in substance, the following question:

> In view of substantial progress in the development of motor-car engine oils, what if any improvements have been made in the last 20 years in the quality of lubricants commonly sold to service stations by yourselves and your competitors for general chassis lubrication?

Note that this does not inquire what improved lubricants are available on *special order* but asks what improvements have been made in the quality of lubricants *commonly sold* through the service stations. I was merely seeking information and did not in the least intend to ask embarrassing questions. However, one of my good friends in this Society, whose duty it was to answer for a well-known company, stated,

> I hardly know how to answer your question—personally, I know of practically no steps which could be called real improvements in the lubricants used. . . . The only new development I can think of is the general improvement in methods of making greases which tends to reduce the proportion of soap that will not stay in suspension. This improvement applies to all greases and, as far as I know, has not been made for any one class of its use.

This is a very frank and fair statement of the situation as I see it. In contrast with all of the radical improvements made in motor-cars in the last 20 years, the quality of lubricant used for general chassis lubrication is substantially the same as it was two decades ago, except for minor refinements in methods of production.

The same member of the Society also wrote:

> We have our own ideas of what should be an ideal lubricant, but we *get very little constructive help from engineers to show what they want*, except their complaints of products with which they are already familiar.

Thus he is putting up to the automotive engineers this important subject in exactly the same frame of mind that I am in; namely, that owners could have better lubricant for general chassis lubrication of their cars if they cared enough to ask for it.

Tests Made with Universal-Joints

Universal-joints probably punish the lubricant worse than any other part of the chassis to which high-pressure fittings are commonly applied, because of the combination of high bearing-pressures, mechanical stirring or manipulation of the lubricant body itself, and espe-

TABLE 1—TYPICAL ANALYSES OF LUBRICANTS THAT, WHEN PROPERLY MANUFACTURED, ARE SUITABLE FOR ALL THE USUAL HIGH-PRESSURE FITTINGS ON THE CHASSIS, INCLUDING UNIVERSAL-JOINTS

Analysis Report No.	219	221	234	237	249	252	254
Reaction	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Free Saponifiable Oil, per cent	1.90	0.44	0.55	0.00	1.75	0.00	0.50
Lime Soap, per cent	0.00	0.00	0.00	0.00	0.00	0.00	3.90
Soda Soap, per cent	8.70	18.00	9.45	14.00	13.30	8.40	12.60
Potash, per cent	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water, per cent	0.10	1.00	Trace	0.15	Trace	Trace	Trace
Mineral Oil, per cent	89.30	80.56	90.00	85.85	84.95	91.60	83.00
Properties of Mineral Oil							
Viscosity at 130 deg. fahr., Saybolt sec.	560	830	380	190	250	590	880
Viscosity at 210 deg. fahr., Saybolt sec.	118	155	82	60	61	105	120
Flash-Point, deg. fahr.	420	460	400	400	405	440	460
Fire Test, deg. fahr.	520	570	435	460	460	495	530
Cold Test, deg. fahr.	40-45	35-40	30	45	35	60	50

cially the centrifugal action already mentioned. The reciprocating action in the universal-joint is very similar to that in the spring-shackle bearings and steering connections. Any lubricant that is good for the universal-joints, therefore, is also good for the other locations referred to; hence most of my mechanical testing of lubricants has been done in connection with universal-joints, both because such tests fitted in with my particular line of work and also constituted the most severe test in actual practice that the lubricants have to withstand.

As a matter of interest, several electric-dynamometer test-stands used in this research are shown in Fig. 1. As will be noted, the variety of size and capacity gives ample variation in load at low and at moderate speeds. A Leeds & Northrup pyrometer is mounted on the instrument board and can be connected to thermocouples through slip rings, the thermocouples being mounted within ⅛ in. of the actual bearing-surfaces in the universal-joints, the intervening ⅛ in. being the wall of the steel bushing, so any temperature variations at the bearing surface will be promptly indicated and recorded. These variations may be caused either by variation in load or by rupture of the oil-film. The slightest variation in load between the maximum and the minimum is promptly and automatically recorded on the temperature chart. Other test-stands not shown provide all speeds up to 6000 r.p.m., or more if desired. At the left of the test stands shown in the background is a large gasoline engine-electric dynamometer unit. The torque capacity of the set in the foreground is 3350 lb-ft.

Let us now see what can easily be accomplished in the way of improvements in lubricants. In general, lubricants made from the higher-viscosity oils will sustain heavier bearing-pressures but will require more powerful guns to handle than will those made from the lower-viscosity oils. To show the rather wide variety of chemical specifications of lubricants that, if properly manufactured, will give good service in chassis parts wherever high-pressure fittings are commonly applied, a list of analyses is given in Table 1.

These analyses represent the material as actually supplied and are not necessarily the exact manufacturers' specifications. They show that the viscosity of the oil varies from 60 to 155 Saybolt sec. at 210 deg. fahr., that the soap content varies from 8 to 18 per cent, and that the variation in the water content present is considerable, although the percentage of water is comparatively small in all cases. The water content is particularly mentioned because, other things being equal, it affects appearance, consistency and other important properties of the finished product. The general character and appearance of all the greases as marketed, the analyses of which are given in the table, are very similar, the most important differences being that some are of considerably longer fiber than others and the range in the apparent consistency is considerable. All of this bears out the statement previously made, that the character of the finished product, so far as outward appearance and ability to withstand centrifugal action of universal-joints are concerned, is controlled nearly as much by the technique of the lubricant manufacturer as by the actual chemical contents of the compound.

Manufacturing technique includes many points, such as the nature of the saponifiable fat used in the preparation of the soap, length of time it is cooked, proportion of water it contains when the mineral oil is introduced, order in which the mineral oil is introduced, if it is a blend as it usually is, and many other details beyond the scope of this paper. This is well illustrated in Table 2 by the two analyses which, from a chemical standpoint, might readily have been included in the list of lubricants in Table 1; but the two lubricants

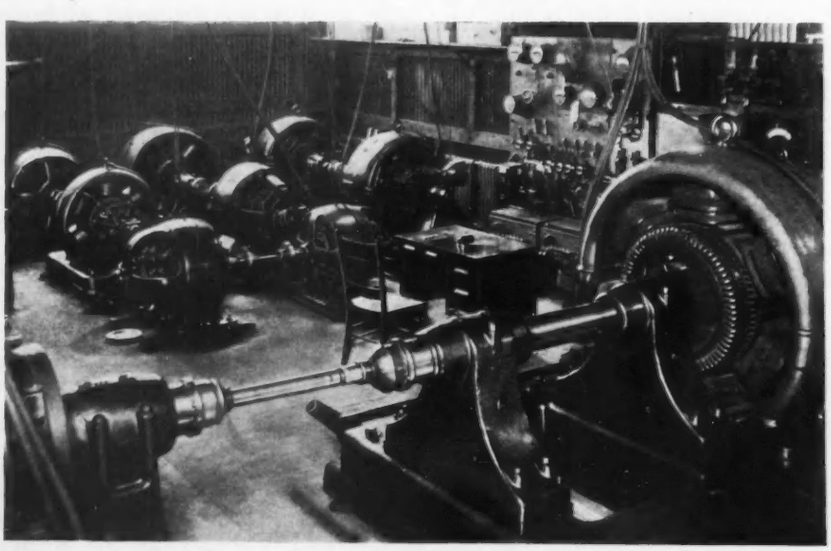


FIG. 1—DYNAMOMETERS ON WHICH MANY OF THE LUBRICANT TESTS WERE MADE

were not satisfactory in use, evidently because the technique of producing the material did not give it the proper physical characteristics to cause it to function satisfactorily.

All concerned should bear in mind that the finished lubricant is no better than the materials from which it is made. I am prompted to make this comment because at least one company having a considerable clientele has attempted to market a lubricant the oil in which is insufficiently refined and contains in various samples from 1 to 3 per cent of asphaltic material. Under heavy-load conditions, with the resulting attendant heat, this asphaltic material tends to gum-up the bearings and clog the passageways, which, of course, is undesirable.

Reduction in Variety of Lubricants Desirable

This is decidedly an age of simplification and standardization. In line with this general program, the fewer the kinds of lubricant that are required for efficient chassis lubrication, the more likely we shall be to obtain satisfactory lubrication of the various parts. The number of special lubricants required for the various parts of the mechanism should be reduced to the minimum. This applies to the car manufacturing company and the large service-station, to which simplification and the minimum number of varieties is extremely important, and also to the small crossroads gasoline and lubricating-oil station that probably has only a single kind of lubricant available for pressure-gun use and a single gun for applying it to the customer's chassis.

Fortunately, the kind of lubricant that best withstands the peculiar requirements of certain portions of the chassis, such as the universal-joints with their centrifugal action, is also one of the best for the other parts that usually are lubricated by means of high-pressure fittings. For example, few of the cup greases commonly used for chassis lubrication will continuously and satisfactorily lubricate such parts as spring-shackles and universal-joints, which have unit pressures as high as 1500 lb. per sq. in. of projected bearing-area. Actually, many of the greases used will carry only 1300 to 1400 lb. per sq. in. On the other hand, all of the lubricants, the analyses of which are given in Table 1, have shown by test that they will continuously sustain at least 2000 lb. per sq. in. of projected area. Under shock load and overload of short duration, the improvement in load capacity is even greater.

As all of our chassis parts must, up to the present, be designed to give reasonably satisfactory service when supplied with a reasonable quantity of even the poorer greases, if we can standardize on lubricants of the better class we can gradually raise our bearing pressures by approximately 50 per cent, thus affording another way of further reducing in important details the already comparatively low cost of our motor-cars.

I have for some years been in touch with the technical departments of many of the leading oil companies of the Central and Eastern States, including a number of companies which cover the world with their service stations, and am glad to be able to state that almost all of these important companies are in position to put a lubricant of the improved type referred to into their service stations immediately, whenever they are made to feel that a sufficient demand for such lubricants exists. Furthermore, several are already supplying such lubricants to all their service stations, and some others tell me they are just about to do the same. I can state confidently that nearly all of the important companies will be in position within the next six months to meet any demands made of them along this line.

Cost of Better Lubricants Not Excessive

Superficially, the average oil salesman will tell his customers that the proposed improved lubricant will cost considerably more money. I regret that some companies are now taking advantage of the situation and charging fancy prices for lubricants of these grades, thereby retarding their rapid introduction. A bit of history in this connection may be of interest. In the early stages of petroleum refining, the principal desired products were lubricating oil and comparatively heavy illuminating oil. Gasoline and all the lighter ends were a drug on the market and large quantities were destroyed. The market value of a petroleum product, up to and including the better grades of high flash-point cylinder-stock, was more or less in direct ratio to its viscosity. Today, the most important products commercially are those on the light end of the refiner's scale, and the natural result is an abundance of the heavy ends at reasonable cost. It may also be noted that the soap content of the lubricant is usually considerably higher in cost per pound than the lubricating-oil content. As the viscosity of the latter is increased, the percentage of soap required to give the proper consistency is automatically reduced, thus reducing the cost of the soap content. Therefore, I find that each of the numerous oil companies with which I have discussed this phase of the question agree that, if the better grade of lubricant can be made in production quantities equal to or greater than the present production quantities of the ordinary cup-greases, the cost of the better grade will be not more than that of the present grades of cup greases and possibly less. In fact, I know a company that is now purchasing the improved grade of lubricant for about 20 per cent less than the regular quotations for corresponding quantities of yellow cup-greases.

To sum up, lubricants much better suited for chassis lubrication than those commonly used are now available, for the asking, at virtually the same cost as the poorer grades. The situation is therefore squarely up to the automotive engineer as to whether he wishes to demand and standardize a better lubricant for the chassis with no increase and even possibly a reduction

TABLE 2—ANALYSES OF TWO LUBRICANTS SIMILAR TO THOSE IN TABLE 1 BUT WHICH FAILED TO FUNCTION SATISFACTORILY IN THE UNIVERSAL-JOINTS BECAUSE OF IMPROPER MANUFACTURING DETAILS

Analysis Report No.	222	228
Reaction	Neutral	Neutral
Free Saponifiable Oil, per cent	0.84	1.20
Lime Soap, per cent	0.00	0.31
Soda Soap, per cent	10.80	7.54
Graphite, per cent	7.15	0.00
Water, per cent	0.10	0.10
Mineral Oil, per cent	81.11	90.85
Properties of Mineral Oil		
Viscosity at 130 deg. fahr., Saybolt sec.	350	300
Viscosity at 210 deg. fahr., Saybolt sec.	90	72
Flash-Point, deg. fahr.	410	400
Fire Test, deg. fahr.	470	450
Cold Test, deg. fahr.	20-25	35

in cost, thereby obtaining longer life of the parts or greater bearing-capacity per square inch of projected area or both, and eliminating some of the present need for special lubricants. Other lubricating engineers besides the one quoted earlier in this paper have expressed their inability to understand the indifferent attitude of the average motor-car engineer on this important subject. Many of the oil companies are ready, and the others will be ready in the very near future. Will the engineer respond?

THE DISCUSSION

A. BRUCE BOEHM[2]:—Mr. Spicer has proved that a lubricant having certain definite characteristics is ideal for universal-joints and has suggested that one way to get the public to use it would be through its adoption by service stations for general use in all chassis pressure fittings. Under existing conditions operators of service stations must view this matter with some doubt. Probably a different lubricant could be made for each chassis part if the ideal were to be obtained in lubrication. This is obviously impractical when applied to service-station operation, but in departing from the ideal a type of lubricant which has seemed to suit the needs has come into general use for chassis service.

To quote Mr. Spicer, "the fewer the kinds of lubricant required for efficient chassis lubrication, the more likely we shall be to obtain satisfactory lubrication of the various parts." The public demands service performed with the minimum loss of time. This has meant the adoption of air-operated grease-guns in the up-to-date stations. Existing equipment is designed to handle grease within certain consistency limits and is entirely unsatisfactory for the greases of high sheer-resistance such as Mr. Spicer recommends. To comply with Mr. Spicer's suggestion, operators of service stations would be faced with scrapping a considerable investment in existing equipment and installing higher-priced and probably more cumbersome equipment if and when such is available. The use of auxiliary guns for universal-joints only, with the present equipment and lubricant for other pressure fittings retained, would also represent additional investment and further complicate and slow-up the servicing operations.

As an explanation of why service-station operators have difficulty in justifying the adoption of either course, a very recent survey made through the personnel of a chain of 200 service stations in one State revealed that, in a period of three months, only two requests had been received for service on universal-joint grease. This means that, with negligible exceptions, the owners and operators of automotive equipment are not at present aware of or interested in any need for an unusual or special lubricant in universal-joints.

We must assume that passenger-car and motor-truck manufacturers have found that the type of lubricant supplied in the field and through the service stations of reputable organizations has been satisfactory and capable of meeting the relatively severe conditions presented in universal-joints, since they have not deemed it necessary to refer to any special lubricant requirements in their instruction books or otherwise. In any event, the public at present is certainly not conscious of any such requirements. As stated by Mr. Spicer, a number of companies are manufacturing the type of lubricant he has described, and as soon as the vehicle manufacturers indicate a need for it and lay sufficient emphasis on the matter through their instruction books and service departments so that the public begins to exhibit some interest in using this lubricant, the service stations will be ready with the necessary equipment for its application to universal-joints and other chassis parts.

Why Grease Is Used

A MEMBER:—What is the relative hydroscopic action of these various soaps? Are the greases containing a more viscous lubricant less likely to become mixed with water, or to become somewhat emulsified?

D. P. BARNARD, 4TH[3]:—We have had in our laboratory, I think, most of the chassis-lubricating systems that have been either proposed or adopted for automobile-chassis lubricating. I have not seen one that would use an oil of 150 sec. viscosity at 210 deg. fahr., for instance, in what we would call winter weather. I do not believe any centralized chassis-lubricating system could handle such a heavy product.

Progress in improving greases is not a very logical question to bring up, as it cannot parallel the improvement in automobiles or in automotive units. The only reason for using a grease is to have a lubricant that will flow under a high shearing-stress but will not flow under a low shearing-stress. It is supposed to be a substance that will flow into the crack where you want it but will not run out of the hole where you do not want it to run. Holes and cracks in housings and similar parts have not changed their properties much in 10 years. Grease that ran out in 1920 will run out of a hole in 1930 under the same actuating conditions. Standardizing on one grease for all the various joints, lubricated by all the different methods that are being used at present, under all of the different atmospheric temperature conditions at which cars are operated, I do not believe is possible.

A MEMBER:—We have found it necessary to build a grease for the gun and not for the centralized chassis-lubricating system. Of an asphaltic-base and a paraffin-base oil both having a viscosity of 300 Saybolt sec. at 100 deg. fahr., it is possible to pump the asphaltic-base oil but not the paraffin-base oil when the temperature falls to 40 deg. fahr. To make our chassis lubricants meet conditions in this territory, we have been compelled to haul oil from the Texas refineries. That is uneconomic but it is a practical solution from the service-station attendant's viewpoint. Until somebody builds a gun to take care of that condition we have either to build more shelves in the service station or forget the matter for the time being.

G. C. HEATH[4]:—We operate a fleet of about 200 motor-trucks throughout the State of Michigan, and

(*Concluded on p. 616*)

[2] M.S.A.E.—Lubrication engineer and sales manager, Standard Oil Co. of New Jersey, Newark, N. J.

[3] M.S.A.E.—Research automotive engineer, Standard Oil Co. of Indiana, Whiting, Ind.

[4] Garage superintendent, Arctic Ice Cream Co., Detroit.

Economic Fuel-Volatility and Engine Acceleration[1]

By DONALD B. BROOKS[2]

ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS AND CHARTS

THIS PAPER is a continuation of one presented at the 1928 Semi-Annual Meeting and gives the results of tests made to determine the effect of the A.S.T.M. 50-per cent point on acceleration and on the most economical fuel-volatility from the standpoint of acceleration.

Test made in connection with the first investigation were on three special fuels and covered a range of manifold temperatures representing the extremes of winter warming-up and summer-operating temperatures. These tests showed a consistent variation in the relative accelerations as the manifold temperature was varied and that the effect on engine acceleration of increasing the A.S.T.M. 50-per cent point volatility is negligbile under most conditions except those under which a car is operated in the summer.

In the second series of tests the objective was the quantity of each of the four special fuels that would give the same acceleration as United States Motor gasoline at an air-fuel ratio of 11.5 to 1. The operating conditions were chosen to give the maximum differences between the fuels used. Data are presented on the relative fuel-flows and approximate estimates of the relative yields from some average crudes.

From the data on relative fuel-flows, it is concluded that the effect of the A.S.T.M. 50-per cent point on the quantity of fuel required to give a stated acceleration appears to be negligible, except under summer-operating conditions. No conclusions are drawn at present from the estimated yields.

IN a paper[3] presented at the 1928 Semi-Annual Meeting, the results of two series of tests made on three special fuels having widely different American Society for Testing Materials 50-per cent points were discussed. In one of these series, practically no differences were evidenced between the fuels; in the second series, at a higher manifold temperature, the accelerations obtained increased with decreasing 50-per cent point. As a result, only specialized conclusions could be drawn. Further tests have since been made, covering manifold temperatures from —10 to 100 deg. cent. (14 to 212 deg. fahr.), representing the extremes of winter warming-up and summer-operating temperatures. The results of all these tests show a consistent variation in the relative accelerations obtained with these special fuels as the manifold temperature is varied.

[1] Published by permission of the Director of the Bureau of Standards, City of Washington.

[2] Jun.S.A.E.—Associate engineer, Bureau of Standards, City of Washington.

[3] See S.A.E. JOURNAL, September, 1928, p. 235.

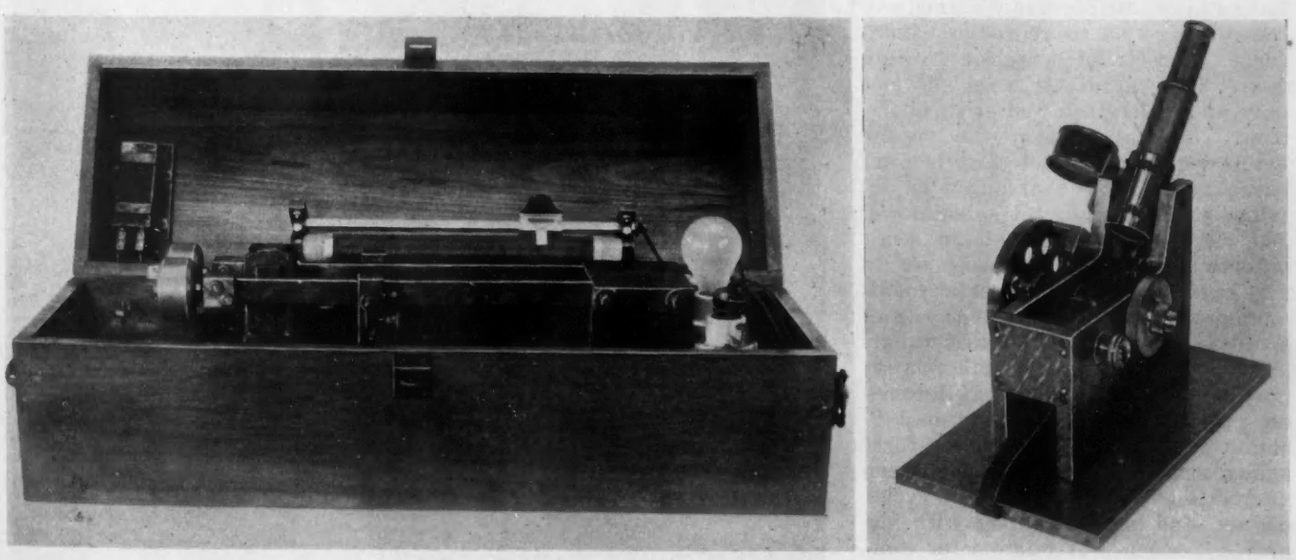


FIG. 1—APPARATUS USED IN CONNECTION WITH THE TESTS

The Tuning-Fork (Left) Used in the Earlier Tests Has Been Altered To Give a Frequency of 6 Cycles per Sec. and Fitted with Improved Contacts. The Micrometer Comparator (Right) Saves Computation, Since Differences of Successive Readings Give Engine Speed Directly

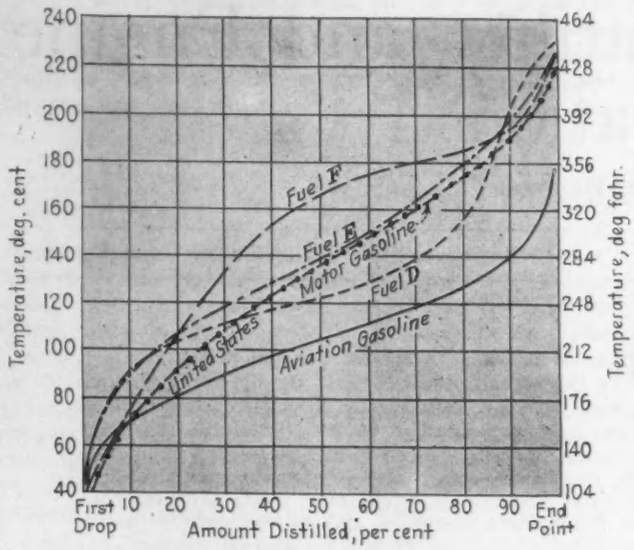


FIG. 2—DISTILLATION CURVES OF THE SPECIAL FUELS AND AVIATION GASOLINE USED IN THE TESTS

Choosing the manifold temperature at which the greatest difference exists between the special fuels, a series of tests was made using two or more air-fuel ratios with each of the fuels. These air-fuel ratios were selected so as to give accelerations both better and worse than a selected standard acceleration, obtained with United States Motor gasoline at an air-fuel ratio of 11.5 to 1. From these tests the relative quantities of each fuel necessary to give the standard acceleration are estimated. The test apparatus used in these tests was essentially the same as that described in the previous paper, consisting of a 3⅛ x 4½-in. six-cylinder three-port overhead-valve engine of 1926 model coupled to a Sprague electric dynamometer. The apparatus attached to the engine was designed and controlled so as to reproduce conditions of level-road operation in high gear. The carbureter used did not have an accelerating well or its equivalent; for this reason the results herein reported are not directly comparable with those that might be obtained with a carbureter so equipped. The manual adjustment of the semi-automatic spark-advance was set to give optimum spark-advance at maximum-power mixture-ratio at the mean speed of the acceleration-test range. This advance was used on all tests reported herein. The spark accelerometer previously described was used to obtain acceleration. The tuning-fork, shown at the left in Fig. 1, had been altered to give a frequency of 6 cycles per sec. and had been fitted with improved contacts[4]. A micrometer comparator, illustrated at the right, has been constructed as outlined in the last paper, saving computation because differences of successive readings give engine speed directly.

[4] See *Journal of Scientific Instruments*, March, 1924, p. 161.

Effect of A. S. T. M. 50-Per Cent Point

The three special fuels were usually run in comparison with aviation gasoline, and distillation curves for these fuels are shown in Fig. 2. The general plan of the investigation of the special fuels has been to operate at a series of manifold conditions such as to cover the maximum possible range of fuel vaporization, since the earlier tests indicated that at least the magnitude of the effect of the 50-per cent point was affected by the conditions governing vaporization. Some idea of one extreme of the range covered may be obtained from Fig. 3, showing the engine being operated with a thick deposit of frost on the manifold.

In operating over such a manifold-temperature range, to use a single carbureter-setting is impractical, as one sufficiently rich to assure eventual acceleration at the lower temperatures would be far too rich at the higher temperatures, particularly in the high end of the speed range. Furthermore, to show the maximum difference in acceleration for a given difference in vaporization between the different fuels is desirable. This necessitates operating with mixtures leaner than that required for maximum power. For these reasons the criterion for carbureter adjustment was the production of an effective air-fuel ratio sufficient to give acceleration with only occasional missing. The resulting adjustment was such as to give about 5 per cent greater fuel-flow than that necessary to ensure eventual acceleration.

Results of tests at six temperatures are shown. Other tests at intermediate temperatures, not shown, check closely the trend remarked in the tests presented. Start-

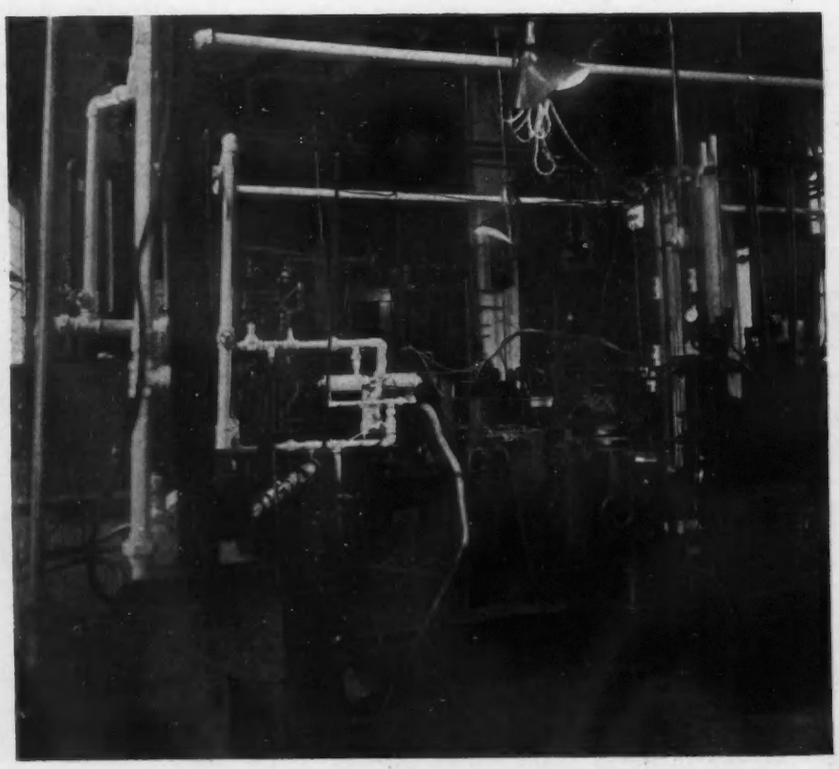


FIG. 3—ONE EXTREME OF THE TEMPERATURE RANGE COVERED IN THE TESTS

ing with the test series at the lowest temperatures, ig. 4 shows the results obtained with the manifold at —10 deg. cent. (14 deg. fahr.) and air supplied to the carbureter at —4 deg. cent. (24.8 deg. fahr.). While the highest acceleration is attained with aviation gasoline, practically no *net* difference between the four fuels over the range from 300 to 700 r.p.m. was observed.

Figs. 5 and 6 show perhaps the most surprising of any results thus far obtained; results that would not be credible were it not for three corroborating series of

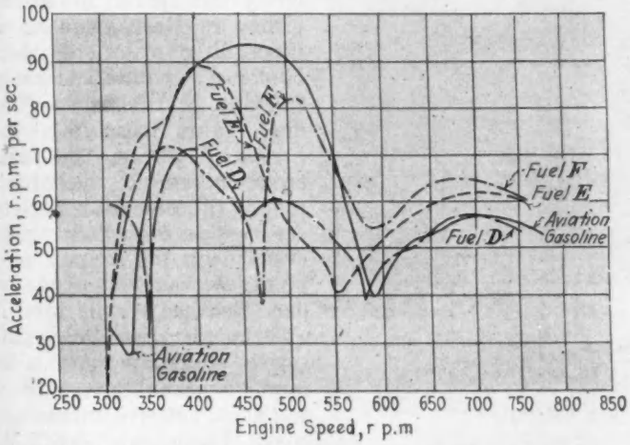


FIG. 4—RESULTS AT ONE EXTREME OF THE TEST RANGE AND A 12.5-TO-1 AIR-FUEL RATIO

The Temperatures in This Test Were: Jacket Water, 86 Deg. Cent. (186.8 Deg. Fahr.); Carbureter Air, —4 Deg. Cent. (24.8 Deg. Fahr.); and Manifold, —10 Deg. Cent. (14 Deg. Fahr.). While the Maximum Acceleration Was Obtained with Aviation Gasoline, Practically No *Net* Difference Between the Four Fuels Was Observable at Speeds Between 300 and 700 R.P.M.

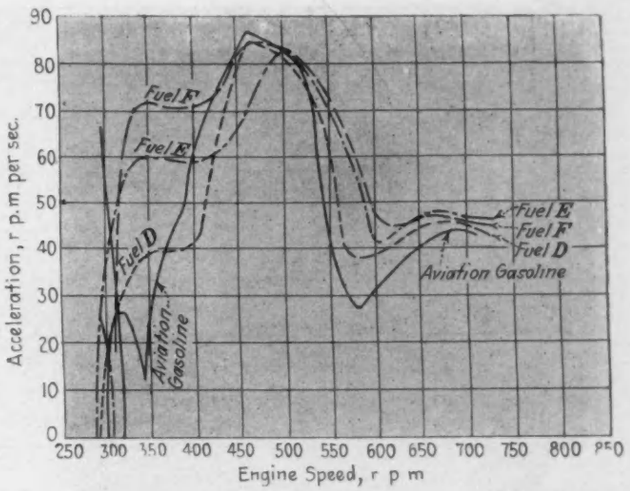


FIG. 5—CURVES FROM ANOTHER ACCELERATION TEST WITH A 10.2-TO-1 AIR-FUEL RATIO

The Temperatures in This Test Were: Jacket Water, 75 Deg. Cent. (167 Deg. Fahr.); Carbureter Air, 25 Deg. Cent. (77 Deg. Fahr.); and Manifold, 10 Deg. Cent. (50 Deg. Fahr.). In This Test the Accelerations Obtained Are in the Reverse Order of the 50-Per Cent Point Volatilities

series are nearly identical with those shown in Fig. 9, except that the performances with the special fuels approach that with aviation gasoline even more closely.

In the entire program of tests at various manifold-temperatures, jacket temperature was maintained at approximately 80 deg. cent. (176 deg. fahr.). Carbureter-air temperature varied independently of manifold temperature, being at room temperature except in tests in the immediate temperature-range. As can be seen from the figures, the accelerations obtained with the manifold at 10 deg. cent. (50 deg. fahr.) are in the reverse order of the 50-per cent point volatilities. In a series of tests at —9 deg. cent. (15.8 deg. fahr.) manifold temperature, this reversal of order can just be noticed; in another series at 2 deg. cent. (35.6 deg. fahr.) it is very obvious; the third series, at 7 deg. cent. (44.6 deg. fahr.) closely checks the results shown in Figs. 5 and 6.

Fig. 7, which is reprinted from the previous paper, shows the results at 43 deg. cent. (109.4 deg. fahr.) manifold temperature. At 32 deg. cent. (89.6 deg. fahr.), as was mentioned in the earlier paper, practically no differences are shown between the three special fuels, but at the higher temperature the accelerations are now in the direct order of the 50-per cent point volatility. This order is maintained at still higher temperatures, as shown in Figs. 8 and 9 taken at 90 deg. cent. (208.4 deg. fahr.) manifold temperature. However, at this temperature, the special fuels are approaching aviation gasoline in performance, as can be seen best from a comparison of Figs. 7 and 9.

By preheating the air supplied to the carbureter, the results shown in Fig. 10 were obtained. The speed-time curves for this

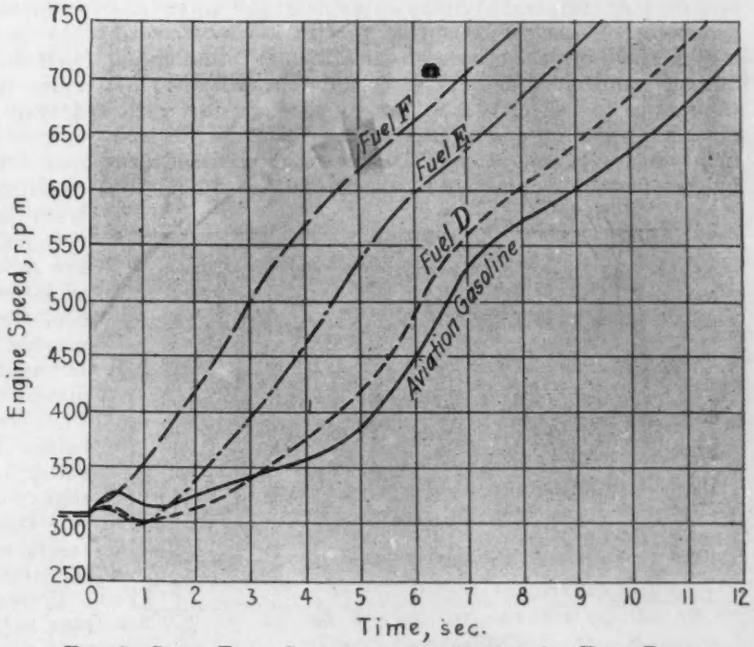


FIG. 6—SPEED-TIME CURVES WITH A 10-TO-1 AIR-FUEL RATIO

This Test Was Made with the Same Carbureter-Air and Manifold Temperatures as Those of Fig. 5. These Results and Those of Fig. 5 Are Perhaps the Most Surprising of Any Obtained in the Tests, but Are Corroborated by Similar Tests Made with Manifold Temperatures of —9 Deg. Cent. (15.8 Deg. Fahr.), 2 Deg. Cent. (35.6 Deg. Fahr.) and 7 Deg. Cent. (44.6 Deg. Fahr.)

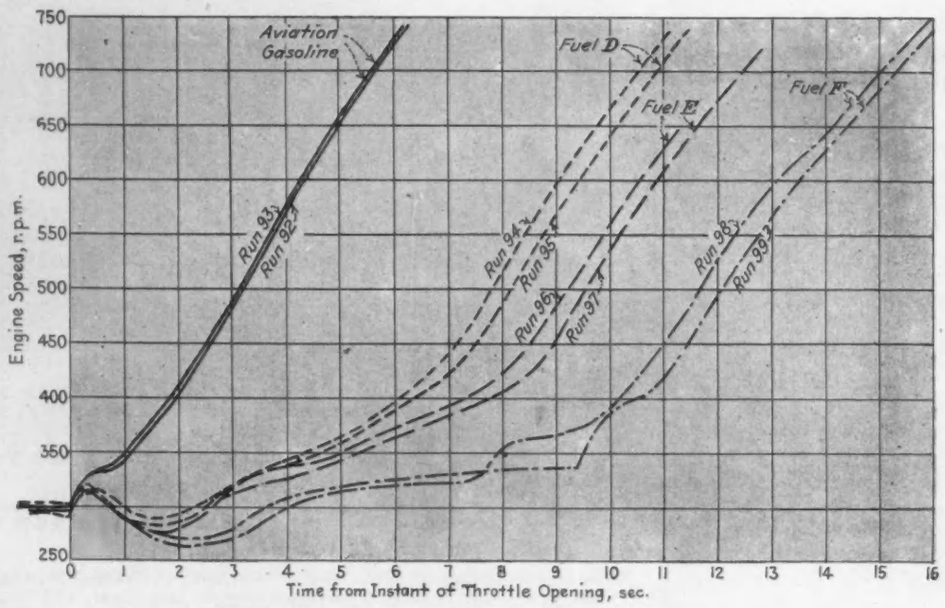


FIG. 7—COMPARATIVE SPEED-TIME CURVES

These Curves Were Obtained with a Jacket-Water Temperature of 88 Deg. Cent. (190.4 Deg. Fahr.) and a Manifold Temperature of 43 Deg. Cent. (109.4 Deg. Fahr.). The Accelerations in These Tests Are in the Direct Order of the 50-Per Cent Volatility

the cases of the tests at the extremes of the temperature range covered. Finally, airflow to the engine was not intentionally restricted, and therefore varied with volumetric efficiency. These factors must be taken into consideration in attempting to correlate the results.

From the observed accelerations the effective air-fuel ratio can be found by the method described in the previous paper. This method is employed, using the observed accelerations, either at or near 350 r.p.m. engine-speed. This speed is chosen with a view toward minimizing both the effects of variations in initial speed and of manifold-wall effects. The reciprocal ratio of the values for effective and for supplied air-fuel ratio gives the fraction of the fuel supplied that is effective in producing acceleration. The values so obtained are independent of volumetric efficiency.

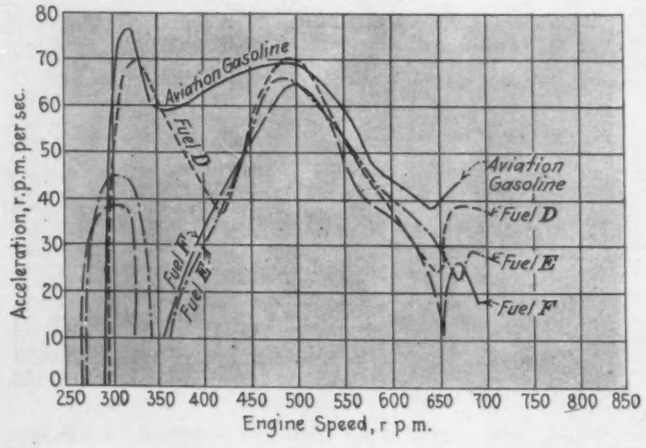


FIG. 8—ACCELERATION CURVES WITH A 16.5-TO-1 AIR-FUEL RATIO

In This Test the Temperatures Were: Jacket Water, 82 Deg. Cent. (179.6 Deg. Fahr.); Carbureter Air, 25 Deg. Cent. (77 Deg. Fahr.); and Manifold, 98 Deg. Cent. (208.4 Deg. Fahr.)

By selecting one fuel as standard and comparing its effectiveness with that of the others, a comprehensive view can be had of the series of tests on aviation gasoline and Fuels *D*, *E* and *F*. This has been done in Fig. 11, in which Fuel *E* has been used as the standard. In this chart the special fuels fall either in the ascending or descending order of their 50-per cent points. At about 310 deg. cent. absolute (558 deg. fahr. absolute) the curves for the special fuels cross, reversing the order, just as the American Society for Testing Materials curves cross near the 20-per cent point, with reversal of order. Because of this fact, it was thought that some qualitative similarity might be found between these curves and some relative curves derived from the A.S.T.M. distillations. The curves of Fig. 12 are derived from the distillations shown in Fig. 2 as follows: With Fuel *E* as standard, the absolute temperatures at successive percentages distilled for Fuel *E* were compared with the absolute temperatures at equal percentages distilled for the other fuels. The curves plotted are relative reciprocal absolute temperatures for equal percentages distilled.

In the case of the special fuels, a certain similarity can be found in the two sets of curves. However, the well substantiated low point on the aviation-gasoline curve in Fig. 11, not having a counterpart in the curve of Fig. 12,, renders it highly improbable that any real connection exists between the two sets of curves. However, evidence from tests on aviation and commercial gasolines and their blend in equal parts is to the contrary, qualitative agreement being shown in that case.

Summing up the results of these tests, the effect of the A.S.T.M. 50-per cent point on acceleration is negligible under winter-operating and summer warming-up conditions. Under summer-operating conditions, a marked effect is shown, the acceleration increasing with increasing 50-per cent point volatility under very low manifold-temperatures, but with a hot jacket, accelerations decrease with increasing 50-per cent point volatility. This latter set of conditions is one occurring rather rarely in practice, as the jacket is usually colder, not hotter, than the manifold. Other tests indicate that, with both manifold and jacket cold, the differences shown above would be diminished very materially.

In conclusion, then, the effect of increasing 50-per cent volatility is negligible under most conditions except those of summer operation. While in practice the most miles are driven under such conditions, in practice, too, the mixtures used are normally sufficiently rich to give, under summer-operating conditions, nearly maximum acceleration with any of the fuels here considered.

This investigation was made to obtain data such as would permit an estimation of the most economical fuel - volatility from the standpoint of acceleration. Since the tests herein reported were made with a carbureter that did not furnish an accelerating charge, the data do not necessarily apply to the carbureters equipped with means for furnishing such a charge. The object of these test runs was to determine the quantity of each fuel necessary to give a certain standard acceleration, a run made with United States Motor gasoline at an air-fuel ratio of 11.5 to 1 being selected as the standard. With each of the four fuels in turn, runs were made with carbureter adjustments such as to give accelerations both greater and less than that obtained in the selected standard run. The operating conditions were chosen to give the maximum differences between the fuels used. From Fig. 11, the maximum difference is seen to occur at a manifold temperature of about 70 deg. cent. or 343 deg. cent. absolute (158 deg. fahr. or 649 deg. fahr. absolute).

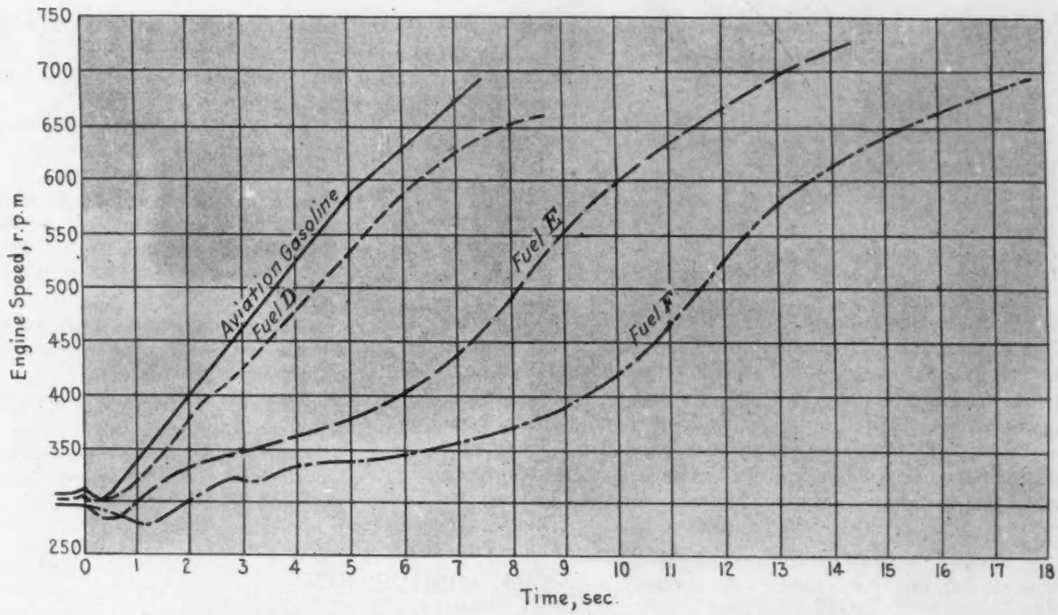


FIG. 9—SPEED-TIME CURVES WITH A 16.5-TO-1 AIR-FUEL RATIO

The Temperatures in This Test Were the Same as Those of Fig. 8. The Special Fuels Are Approaching Aviation Gasoline in Performance, as Can Be Seen by Comparing This Chart with Fig. 7

Fig. 13 shows the acceleration-speed and speed-time curves for the selected standard run with United States Motor gasoline, while Figs. 14 and 15, showing the acceleration-speed and speed-time curves for fuel *D*, illustrate the type of curves obtained in the comparative tests. The numbers on the curves of these two figures are the identification numbers of the carbureter metering-orifices used. These charts show that with orifice 64 somewhat better acceleration was obtained than in the case of the standard run, while with orifice 61, the acceleration obtained was less than the standard. A rough interpolation can be made between the two orifices for the fuel flow that would give an acceleration equal to that of the standard run. This interpolation is made on the acceleration-speed curve for the following reason. At air-fuel ratios greater than that giving maximum power, brake torque, and consequently acceleration, varies roughly in proportion to the fuel flow. Hence a linear interpolation between the two observed accelerations will give an approximately correct value of the desired fuel-flow. From Fig. 15 it is obvious that linear interpolation between the speed-time curves would give an erroneous result.

In this manner, the fuel flow required to give acceleration equal to that of the standard run was estimated for each of the four fuels. The values so obtained, relative to the flow required with United States Motor gasoline, are shown in Table 1, together with rough estimates of the relative yield of each of the fuels from some average crudes. For reference, a distillation curve for the sample of United States Motor gasoline used in these tests is shown in Fig. 2.

From the second column of Table 1 it is seen that when operating at 70 deg. cent. (158 deg. fahr.) manifold and jacket temperatures, and with a carbureter not equipped with an accelerating well, the quantity of fuel required to give equal acceleration increases with increasing 50-per cent point. These quantities are approximately in the reciprocal ratio of the effectiveness

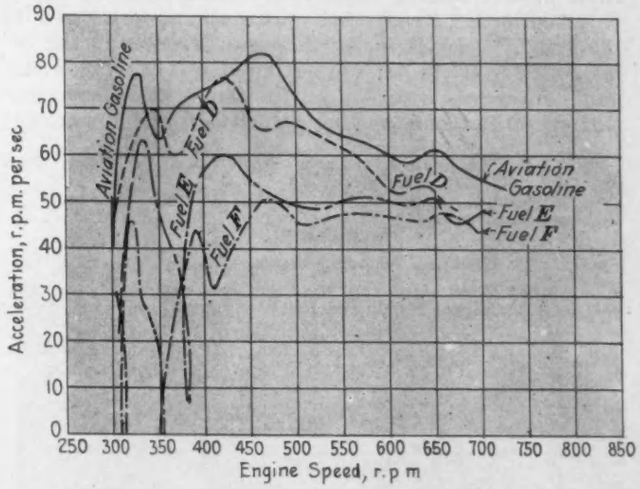


FIG. 10—EFFECT OF PREHEATING THE AIR SUPPLIED TO THE CARBURETER

The Temperatures in This Test Were: Carbureter Air, 63 Deg. Cent. (145.4 Deg. Fahr.); and Manifold, 85 Deg. Cent. (185 Deg. Fahr.). The Speed-Time Curves for This Series Are Nearly Identical with Those of Fig. 9, Except That the Performances with the Special Fuels Approaches Even More Closely That with Aviation Gasoline

TABLE 1—RELATIVE FLOW OF VARIOUS FUELS REQUIRED FOR EQUAL ACCELERATION

Fuel	Volume Required	Estimated Yield Range Per Cent	Per Cent	Average Per Cent
United States Motor Gasoline	1.00	..	..	100
Aviation Gasoline	0.73	55	86	62
D	0.96	80	94	86
E	1.10	100	117	108
F	1.16	105	120	107

for acceleration values shown in Fig. 13. In considering the second and last columns of Table 1, it should be borne in mind, first, that the relative fuel-flows are those at conditions giving the greatest possible differences between the fuels, as regards both engine temestimates of yields are not to be regarded as either repperatures and carburetion system; and, second, that the resentative or even approximately correct, as can be seen from the column giving the range over which estimates from different sources varied. They should be used with caution. No conclusions will be drawn from these data at present.

The following conclusions are drawn from the data available at present:

(1) The effect of the A.S.T.M. 50-per cent point on engine acceleration, or on the quantity of fuel required to give a stated acceleration, appears to be negligible, except under summer-operating conditions

(2) Under summer-operating conditions, unless special accelerating devices are provided, the acceleration improves or the required fuel decreases, with decreasing A.S.T.M. 50-per cent point

(3) Current practice in carbureter adjustment makes it probable that some increases in fuel consumption would follow an increase in the A.S.T.M. 50-per cent point

THE DISCUSSION

CHAIRMAN NEIL MACCOULL[5]:—These three special fuels Mr. Brooks mentioned were specially made up so as to have no variation between them except in the middle portion of the distillation curves. They all come fairly close at the 20 and 90-per cent points, and the object of the investigation was to determine how much the 50-per cent point of the curve meant to engine operation. To learn that what we normally consider the poorest fuel gives the best results in winter and the poorest results in summer is interesting, and we would like to hear an explanation for it.

PROF. GEORGE G. BROWN[6]:—While what I have to offer may or may not be of direct value, I think it worth mentioning at this time because, in making these acceleration tests, important conditions are found which do not exist in determining equilibrium volatility. The work reported by Mr. Brooks was apparently undertaken with the prime object of investigating differences in the 50-per cent point. In our work at the University of Michigan, differences over the entire range have been considered rather than limiting ourselves to the 50-per cent point. We are entirely in agreement with the conclusion Mr. Brooks has presented, that the 50-per cent point is a fairly satisfactory indication of the effective volatility of a motor fuel used under summer warming-up or winter-driving conditions.

However, when we operate the engine under lower temperature-conditions, it seems reasonable to expect that we should compare the A.S.T.M. distillations at some lower temperature in the same way that Dr. Bridgeman has compared the A.S.T.M. Distillation Curve and the equilibrium-distillation curve. Careful consideration of the Fuels *D*, *E* and *F* has indicated that they are practically the same at the 20-per cent point but not the same at lower percentages. In our test at the University, we have observed practically the same difficulty, that slight differences in the early part of the curve will make very appreciable differences in the response of the engine.

Another point I think worth mentioning is that, during acceleration conditions, the engine undoubtedly burns more fuel than is actually vaporized. A very appreciable quantity is carried into the manifold as mist or in drops or possibly swept along on the manifold walls as a film so that perhaps, if a fuel shows 40-per cent effective volatility, we may subtract 30 per cent

[5] M.S.A.E.—Automotive engineer, The Texas Co., New York City.

[6] M.S.A.E.—Professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

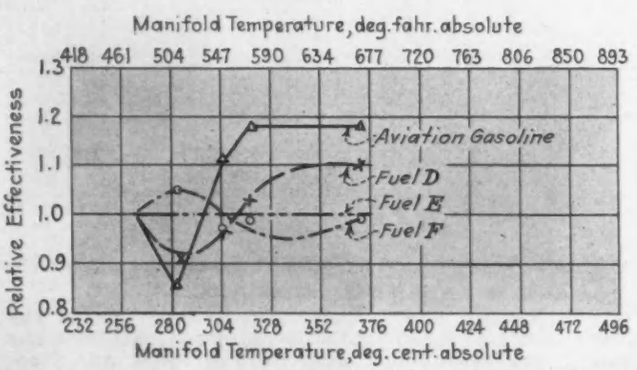


FIG. 11—RELATIVE EFFECTIVENESS OF VARIOUS FUELS TESTED

Fuel *E* Has Been Selected as the Standard with Which the Other Fuels Were Compared

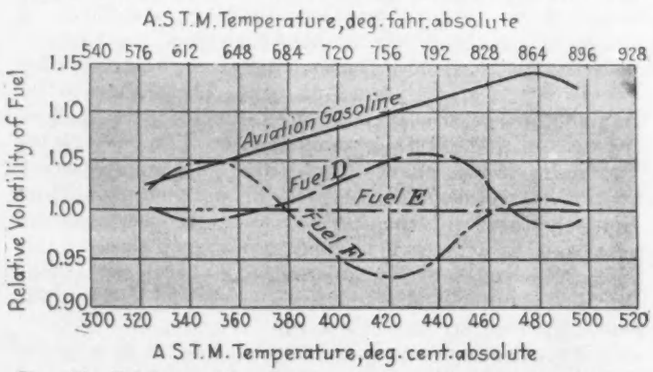


FIG. 12—RELATIVE VOLATILITIES OF THE FOUR FUELS TESTED

These Curves Are Derived from the Distillation Curves of Fig. 2, Fuel *E* Again Being the Standard of Camparison

from that as being drops, mist or liquid carried in and burned, leaving the 10-per cent point as the point on the A.S.T.M. Distillation Curve that might indicate 40-per cent effective volatility, just as Mr. Brooks has found that the 50-per cent point indicates an effective volatility of somewhere between 60 and 70 per cent. This is not precise in any sense of the word; it is simply a suggestion that may be of value.

CHAIRMAN MACCOULL:—That is a good explanation. When I first saw that these data were obtained on an engine that had no accelerating well, I was a little dis-

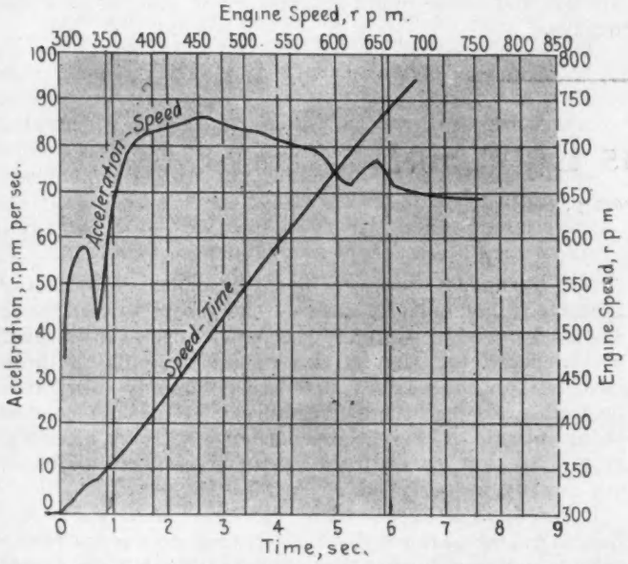


FIG. 13—ACCELERATION-SPEED AND SPEED-TIME CURVES OF UNITED STATES MOTOR GASOLINE

appointed, but we must realize that an accelerating well is a very much unwanted accessory on the carbureter. If you can learn all the facts and get away from the carbureter that has an accelerating well, I think everybody would prefer it. This is certainly the way to start, and I feel sure that the Bureau of Standards will continue the work later on with accelerating wells.

Fuel Need Not Be Vaporized

JOHN O. EISINGER[1]:—From his data, can Mr. Brooks at this time tell us exactly, or, if not exactly, within general limits, how much of the charge at any temperature should be vaporized to give satisfactory performance? Is it 5, 10 or 20 per cent? For instance, what is the percentage of the fuel for a 12-to-1 mixture that should be in the vapor state to give satisfactory acceleration?

MR. BROOKS:—That depends on the quantity supplied. From the tests we have made on acceleration at low temperatures, we have no reason to believe that the fuel needs to be vaporized at all to be burned and give acceleration. That is to say, every evidence of apparently satisfactory combustion of the atomized fuel is present.

MR. EISINGER:—If you can atomize a fuel, it is not necessary to vaporize a very large proportion of it?

MR. BROOKS:—That seems to be the case.

MR. EISINGER:—Is it not true that differences in en-

[1] M.S.A.E.—Research engineer, Standard Oil Co. of Indiana, Whiting, Ind.

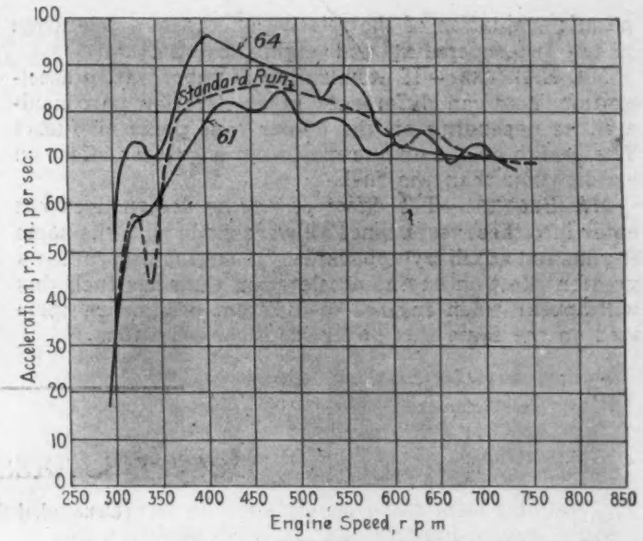


FIG. 14—ACCELERATION-SPEED CURVES OF FUEL *D*

The Numbers on Two of the Curves Designate the Metering Orifices Used. The Third Curve Is the Standard Run with United States Motor Gasoline

gines and auxiliary equipment, such as intake manifold, carbureter and the like, may give greater differences in acceleration than the maximum differences found between the three test fuels having different 50-per cent points?

MR. BROOKS:—Speed-time tests made using the chronometric tachometer showed negligible differences in the performance obtained with different carbureters, but a decided difference between different manifolds. Since the development of more precise instrumentation, no tests have been made to determine the relative importance of the design factor in engine acceleration. A program of identical tests on a number of engines is at present being developed. Data derived from this program will supplement present information so as to

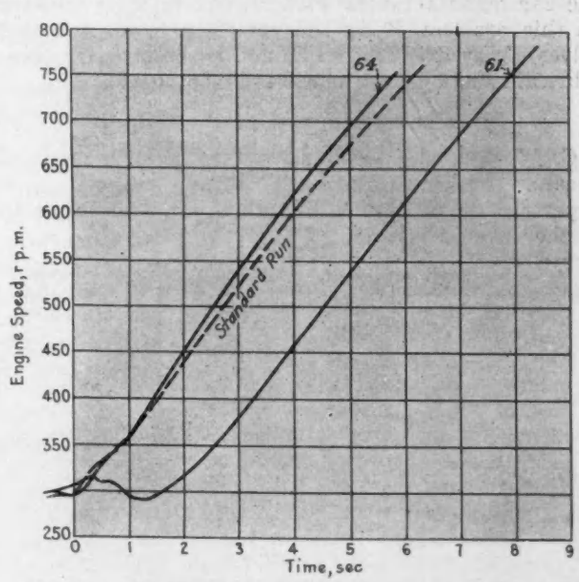


FIG. 15—SPEED-TIME CURVES OBTAINED WITH FUEL *D*

These Curves and Those of Fig. 14 Illustrate the Type of Curves Obtained in the Comparative Economic Fuel-Volatility Tests

permit evaluation of the relative effects on acceleration of the fuel, operating and engine-design factors.

MR. EISINGER:—If atomization is important in acceleration, how can differences in acceleration be considered as depending on the 50-per cent point of fuels? The design of the engine may have a greater effect on acceleration than the fuel.

MR. BROOKS:—The effect of engine design does not enter into these tests, since all were made with the same engine and auxiliary apparatus. If engine design has a greater effect on engine acceleration than has fuel, this will appear when engines of different design are operated on the same fuel under identical conditions.

Differences in engine acceleration can be considered as depending both on atomization and on fuel volatility; the importance of one does not counteract the effect of the other. Under the conditions of some of the tests described in the paper, it can be shown that neither atomization nor vaporization alone would have produced a mixture sufficiently rich to fire. As vaporization increases, obviously, atomization becomes less important. The differences in acceleration between the three special fuels can be ascribed to differences in vaporization with considerable certainty, as these fuels are physically very similar and hence would be expected to atomize to a like degree.

Better Chassis Lubricant

(*Concluded from p. 608*)

for proper chassis lubrication I found it necessary to use several types of grease in the different places, for instance, a fiber grease in the wheel bearings and universal-joints, and a special fitting. I did not find any of the Alemite fittings that would handle a heavy enough lubricant. I have used Dot fittings and a Dot gun, and they gave better results where we used the heavier grease. After a test of about one year on spring-shackles, I found that feeding a light oil through a wick by capillary attraction has doubled the life of the shackles.

CHAIRMAN GEORGE A. ROUND[8]:—Unquestionably we have several different ways of attacking the chassis-lubrication problem. Mr. Spicer's paper seems to me to be along the lines of providing a better lubricant for one existing lubricating system. The merits of the various systems are still a matter of controversy, partly based on price. I think that we should hear more from the car manufacturers with respect to their viewpoint on this problem, if we can get them to express themselves. Why is it that we do not get both better chassis lubricants and better chassis lubrication?

Public Uninformed on the Subject

C. W. SPICER:—Replying to the first inquiry, the question of emulsification is briefly covered in the paper. I have no data on the relative hydroscopic action of the various soaps.

[8] M.S.A.E.—Assistant chief, engineering division, automotive department, Vacuum Oil Co., New York City.

Mr. Barnard's question regarding chassis-lubricating systems is not entirely clear; if he refers to central or so-called one-shot systems, my paper specifically stated at the beginning that it was meant to apply to those locations on the chassis that are commonly lubricated by high-pressure fittings, temporary fittings, of course, being intended. I see no reason, however, why a central system to take care of the material referred to could not readily be designed.

I heartily disagree with the implications of Mr. Boehm's first paragraph. Lubrication versus no lubrication, and good lubrication versus poor lubrication are, after all, only comparative. We all agree that thorough lubrication with even a poor lubricant is far better than no lubricant at all. That is why the situation is so much better today than it was a few years ago and the public is satisfied because it does not know of any lubricant that is easily available which will give 50 per cent still better results. Many motor-car manufacturers are using the better lubricants in their new chassis before shipment, and the larger service-stations are using them afterward. I thank Mr. Boehm for confirming in his last paragraph my expressed opinion that the service stations will promptly respond with lubricant and lubricating equipment whenever the engineers call for it in their instruction books or whenever the public becomes otherwise informed. If it is worthwhile, as experience has proved, for car manufacturers and fleet operators to use the better lubricants, why not let the public in also?

Aluminum for the Automotive Industry

By Dr. Zay Jeffries[1]

Southern California Section Meeting Paper — *Illustrated with* Photographs

An outline is given of the strength that can be expected from various cast and wrought aluminum alloys, with the heat-treatment necessary to develop the best strength.

Intercrystalline embrittlement, which causes trouble with thin sheets of aluminum alloy used around salt water, is explained. The remedy offered is a thin coating of practically pure aluminum, which is free from attack and protects the stronger alloy both mechanically and dielectrically.

Magnesium-alloy castings now are being made commercially, and sample parts for aeronautic engines and starters are shown in photographs.

In the discussion, Dr. Jeffries amplifies some of the information on heat-treatment, forging and application of aluminum alloys, and says that natural aging tends to increase somewhat the yield-point and tensile strength of some alloys, at the same time decreasing slightly the elongation.

COMMERCIALLY pure cast aluminum has a tensile strength of 12,000 to 14,000 lb. per sq. in., and heat-treated cast alloys have a maximum tensile strength of about 45,000 lb. per sq. in. The elongation diminishes from 15-25 per cent in the pure aluminum to 0-2½ per cent in the strongest heat-treated alloy.

The development of high strength in castings has been made possible by heat-treatment. I shall discuss the general theory of the heat-treatment of aluminum castings, and similar principles will apply to the heat-treatment of the wrought strong aluminum alloys. Fig. 1 represents a micrograph of aluminum alloy containing 5 per cent of copper and 95 per cent of aluminum. The white material is solid solution of copper and aluminum, and the network material contains eutectic of aluminum-copper in solid solution and the compound $CuAl_2$. The material is relatively weak and brittle, because fracture takes place along the network lines at a load so small that insufficient tension has been put on the solid-solution portion of the alloy to cause maximum permanent elongation. This is known as the "O" condition of the alloy.

After heating to a temperature of about 520 deg. cent. (968 deg. fahr.) for a period varying from a few hours to 24 hr., followed by rapid cooling, the structure shown in Fig. 2 results. The network has disappeared. The $CuAl_2$ has been dissolved by the aluminum-rich solid solution, and rapid cooling after the heating preserves substantially the solid-solution structure. Such a treatment, designated "W," will increase the tensile strength 50-100 per cent, and often more than double the elongation. In the commercial alloys, the average tensile strength will be 33,000 lb. per sq. in., with 8-9 per cent elongation before rupture.

This material can be further strengthened and hardened by the "T" treatment, that is, artificial aging, by heating at 150 deg. cent. (302 deg. fahr.) for a period of a few hours or more. The longer the heating, up to a certain point, the harder and stronger the final alloy becomes, but lower elongation accompanies maximum hardness. A variety of properties can be obtained by varying the heat-treatment without material change in the chemical composition. The increase in strength and hardness produced by aging at about 150 deg. cent. is due to the precipitation of myriads of submicroscopic particles of hard compound within the grains and at the grain boundaries of the aluminum-rich solid solution.

In the heat-treatment of the wrought alloys, since the network structure has been previously broken down by the mechanical working, the high-temperature or solution heat-treatment may require only a few minutes. The heat-treatment of the wrought alloys is somewhat similar to that of the cast alloys with the exception of the time element. The cast alloys, in addition to having a different composition, must be given a considerable time at the high temperature.

In 17S alloy, containing 4 per cent of copper and 5 per cent each of manganese and magnesium, room-temperature age-hardening occurs spontaneously after quenching. In certain types of strong alloy, higher aging temperatures may be required to bring out the maximum properties. Alloy 25S, which contains 4 per cent of copper, 5 per cent of maganese and no magnesium, must be heated for several hours at about 150 deg. cent. (302 deg. fahr.) after quenching, to develop its maximum strength. The W condition represents room-temperature aging but no artificial aging. Any set of properties between the W condition and the T condition can be obtained by varying the artificial aging treatment. Alloy 25S is quite stable after the quench at room temperature. Alloy 51S, containing 0.6 per cent of magnesium, 1 per cent of silicon and no copper or manganese, ages to some extent at room temperature, but the tensile strength rises further after artificial aging.

The hardness of 51ST is about equal to that of duralumin and 25ST. The 25S alloy is used in propellers in the forged condition. It develops the same properties as 17S and forges more readily. The propeller which

[1] M.S.A.E.—Consulting metallurgist, Aluminum Co. of America, Cleveland.

Lindbergh used in his famous flight to Paris was made of 25S alloy, heat-treated to the T condition. This 25S alloy was developed in America, whereas duralumin was developed by Alfred Wilm in Germany. The advantage of 51S lies in its ease of mechanical working. The forged crankcases and nose-pieces of the Pratt & Whitney aircraft engines are made of 51S alloy.

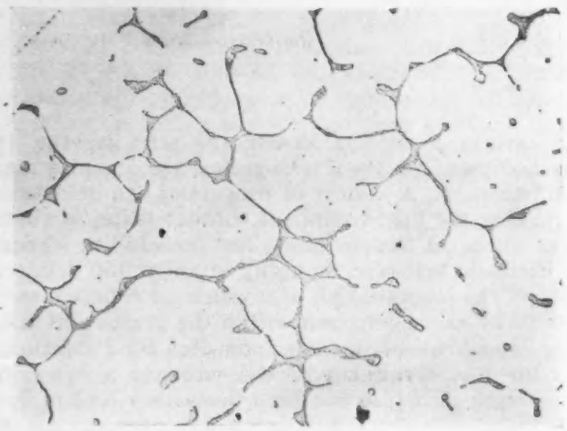


FIG. 1—MICROGRAPH OF CAST ALUMINUM WITH 5-PER CENT COPPER ALLOY, UNETCHED—MAGNIFICATION 100 TIMES

These are the three leading wrought-aluminum alloys used for aircraft construction, 17S being used mostly in tubing and sheet form, and the other two as forgings. The compositions and properties of these and other aluminum alloys are tabulated in a paper by R. S. Archer.[2] The table of Properties of Steel and Aluminum Beams of Geometrically Similar Cross-Section is repeated herewith as Table 1, because of the typographical errors in printing it as Table 6, in Mr. Archer's paper.

Salt Water Attacks Thin Sheets

A type of corrosion known as intercrystalline embrittlement appears in thin sheets of duralumin or any of the wrought strong alloys when used around salt water. If the larger cast and forged sections are corroded in the same way, the effect is not so serious. The attack begins at the surface and works inward, so a small surface-attack may affect a considerable percentage of the thickness of a thin sheet. The protection of strong-alloy sheet for use in aircraft structures around salt water has been a difficult and serious problem. Many things have been proposed and tried to meet that condition, such as anodic-film protection, bitumastic paint, aluminum paint, and ordinary grease.

The Bureau of Standards discovered that coating with a fairly pure aluminum by means of a spray gun greatly improved the protection of duralumin against salt-water corrosion. The Aluminum Co. of America has worked out another method of surfacing a strong alloy, such as 17S, with practically pure aluminum to produce a composite material. Alclad 17S sheet seems to be quite immune from salt-water or salt-spray corrosion. The protection is effective on more than the portions actually covered with the pure aluminum. Fig. 3 is a micrograph of a piece of Alclad 17ST, with the alloy exposed at the cut end, which has been exposed to a salt spray for 18 weeks and etched with ½-per cent hydrofluoric acid. The magnification is 100 times. No corrosion is seen, even of the portion where the alloy is unprotected by the coating, because the pure aluminum has a higher solution pressure than the 17S, and protects it electrolytically. Fig. 4 shows ordinary 17ST that has been treated in the same way. Fig. 5 shows a Fairchild cabin monoplane equipped with pontoons that are covered with Alclad 17ST sheathing. A wing rib, stamped

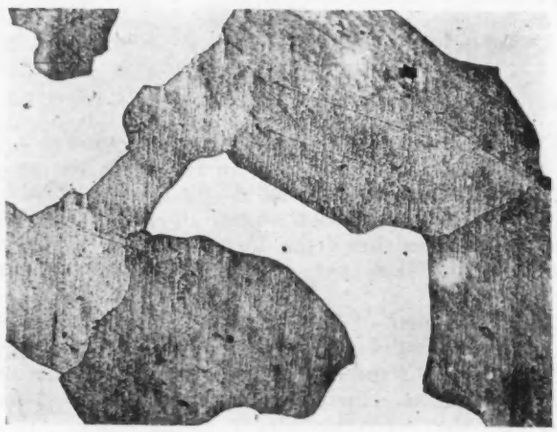


FIG. 2—MICROGRAPH OF SAME ALLOY AS IN FIG. 1, AFTER HEAT-TREATMENT, ETCHED—MAGNIFICATION 100 TIMES

TABLE 1—PROPERTIES OF STEEL AND ALUMINUM BEAMS OF GEOMETRICALLY SIMILAR CROSS-SECTION

	Steel	Aluminum	Aluminum	Aluminum
a	1	1	1.320	1.68
a^2	1	1	1.732	2.82
a^3	1	1	2.280	4.74
a^4	1	1	3.000	7.98
Weight	100	35.4	61.4	100
Strength	100	50.0	114.0	237
Stiffness	100	33.3	100.0	265

Assumptions Made

	Steel	Aluminum
Specific Gravity	7.9	2.8
Young's Modulus, lb. per sq. in.	30,000,000	10,000,000
Tensile Strength, lb. per sq. in.	100,000	50,000

Note.—For simplicity of comparison, a square section is assumed. The letter a represents the length of the side of the square. For beams of equal stiffness, the weight of the aluminum is 61 per cent of that of the steel, and its strength 114 per cent. For beams of equal weight, the stiffness of the aluminum is 265 per cent that of the steel, and its strength 237 per cent.

(From S.A.E. JOURNAL, August, 1928, p. 156.)

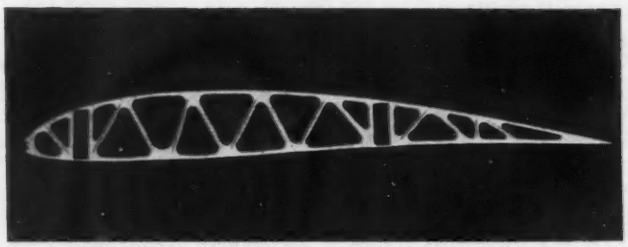


FIG. 6—ONE-PIECE WING-RIB FOR CURTISS ROBIN AIRPLANE

[2] See THE JOURNAL, August, 1928, p. 149.

FIG. 5—FAIRCHILD CABIN MONOPLANE WITH 17ST-ALCLAD-SHEATHED PONTOONS

from a single sheet of 17ST Alclad is shown in Fig. 6. This rib weighs 0.59 lb. and is designed to support a uniformly distributed load of 540 lb. in the Curtiss Robin airplane.

Magnesium-Base Alloys

In addition to the aluminum-base alloys, which are now very important materials in aircraft construction, we are now able to announce definitely that the use of magnesium-base alloys has passed the experimental state. Cooperative effort for the last several years between the Aluminum Co. of America, the Dow Chemical Co., the American Magnesium Corp., several departments of the United States Government, the Curtiss Aeroplane & Motor Co., the Pratt & Whitney Aircraft Co., and the Eclipse Mfg. Co., has resulted in the actual making of magnesium-base-alloy castings for production parts.

Production castings of magnesium alloy are shown in Fig. 7. The two groups at the left are parts for aeronautic-engine starting-motors and the two groups at the right are airplane-engine parts.

THE DISCUSSION

QUESTION:—What is used as a quenching medium in aging aluminum castings?

DR. ZAY JEFFRIES:—Some form of rapid cooling is essential for the development of maximum strength after the high-temperature heat-treatment; but it makes little difference how the alloy is cooled after it has been aged. If it is heated to 150 deg. cent. (302 deg. fahr.) and quenched in water or oil, it has the same characteristics as if it were cooled in air.

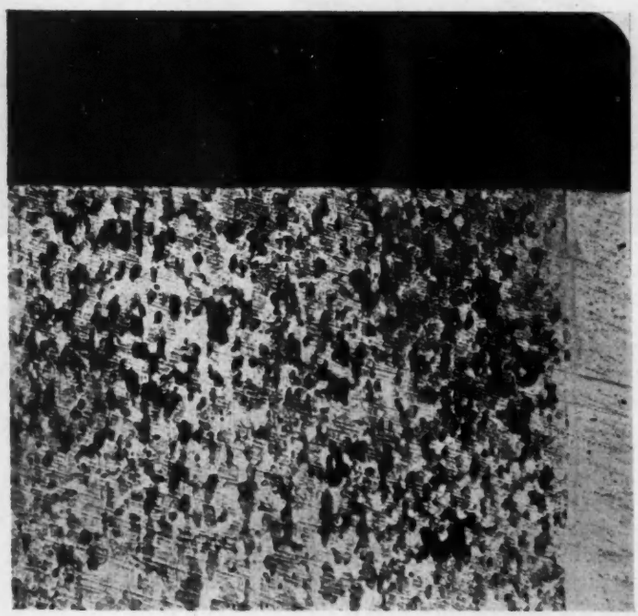
JOHN MCGEORGE[3]:—What are the methods used in forging; are the parts heated and forged by pressure, or are they forged by hammer?

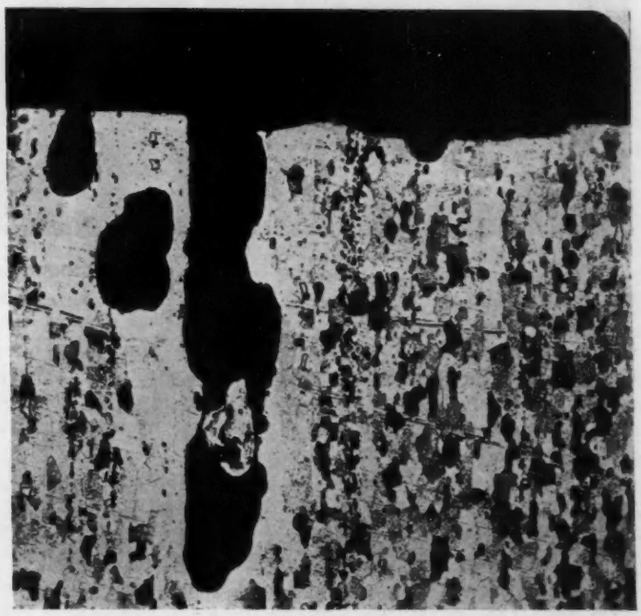
DR. JEFFRIES:—The forging is done hot, and so far it is hammer forging.

J. H. KINDELBERGER[4]:—Some time ago I received from the Army a report of a series of experiments on the aging of various copper-aluminum-alloy castings which showed that an alloy such as 195HTT will have an elongation of from 6 to 11 per cent, when aged artificially, but that this elongation drops to about 5 per cent in atmospheric temperature within 2 or 3 years.

DR. JEFFRIES:—This alloy, like many aluminum-

[3] M.S.A.E.—Consulting engineer, Los Angeles, Calif.
[4] Chief engineer, Douglas Aircraft Co., Santa Monica, Calif.





TESTS OF ALUMINUM ALLOY FOR CORROSION

FIG. 3—ALCLAD SHEET FIG. 4—NORMAL SHEET

Tensile Specimens of 14-Gage 17ST Sheet Were Exposed to Salt Spray for 8 Weeks Both Samples Have Been Etched with ½ Per Cent Hydrofluoric Acid. The Magnification Is 100 Times

copper alloys, does age, and the tendency is for the elongation to decrease somewhat and the yield-point and tensile strength to increase. One of the main advantages of the high elongation of the heat-treated castings is for the processes of fabrication. The castings can be abused and straightened without breaking during transportation and machining. The fact that these alloys do age should not be at all disturbing, because all of the ordinary aluminum-alloy castings with copper as the principal alloying element have been going through this aging process since the beginning of the aluminum-castings industry. The increase in strength and yield-point may be quite desirable in service, and the slight decrease in elongation may not be at all objectionable.

J. J. MURRAY[5]:—Has forged aluminum been applied successfully for the master and articulated connecting-rods of radial aircraft engines?

DR. JEFFRIES:—So far as I know, no production engines are made using aluminum as the connecting-rod material for either the master rod or the link rod, but experiments are going on in several places which indicate that strong wrought-aluminum alloys may be considered as at least a potential material for this use.

R. A. WEBSTER[6]:—What is the proper method of testing Alclad sheet for hardness?

DR. JEFFRIES:—I believe that no satisfactory method has been worked out for this; the only safe guide is the tensile strength, although that cannot always be applied. If the tensile strength is high, the hardness will be high.

A MEMBER:—Is the chemical breaking-down of the network in wrought aluminum-alloys a chemical or a mechanical process?

DR. JEFFRIES:—It is a little of each; the network structure is elongated in the working, and the particles of hard compound are broken up and surrounded by the aluminum solid solution during this process. The temperatures used during the mechanical working help to absorb some of the CuAl, into the solid solution.

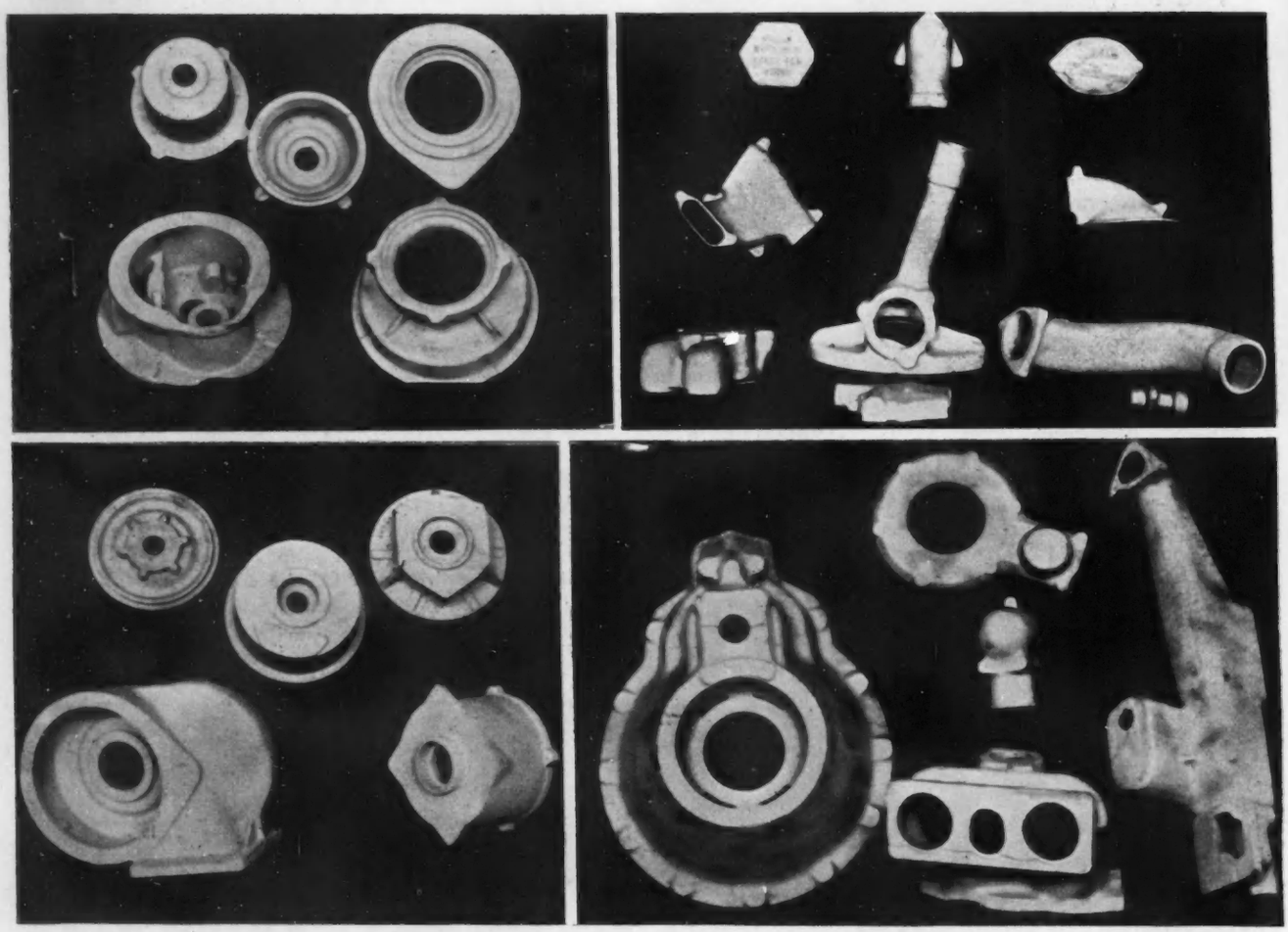


FIG. 7—MAGNESIUM-ALLOY SAND-CASTINGS

The Two Groups at the Left Are of Housings for Airplane Starters; the Two Groups at the Right Are of Airplane-Engine Parts

[5] M.S.A.E.—President, Aircraft Holding Corp., Culver City, Calif.

[6] Douglas Aircraft Co., Santa Monica, Calif.

Applying the Motor-Vehicle to Business

By W. F. Banks[1]

Transportation Meeting Paper

MANY FACTORS gradually forced a recognition of motor-vehicles as necessary adjuncts to business, and now the motor-vehicle is being called upon more than ever before to serve also as a labor-saving device. The author believes that present-day business will demand further development of this nature.

The groups interested in establishing and developing the motor-vehicle in business are the manufacturers thereof, the commercial organizations operating vehicles for their individual needs, the commercial operators supplying service for a variety of customers, and the railroads. The author pays tribute to the manufacturers for the present dependability of motor-vehicles and comments upon the extension of motor-vehicle service in the respective fields of the three other groups.

Present competition in all forms of business makes the problem of cost accounting equally serious for all users of commercial vehicles, in the author's opinion. He cites instances to show how little consideration this subject is given. Considering the entire field of the application of commercial vehicles, there is to him no problem more important to all users of these vehicles than that of an adequate cost-system which should present a true picture of the total cost of owning and operating motor-vehicles, be sufficiently uniform to serve all users, make possible a true comparison of at least some phases of operation, and allow the proper application of costs to individual jobs for the commercial operator. Only through the proper and practical use of cost data can both the buyer and the seller be brought to the mutual understanding which is necessary to establish the economic value of motor-vehicle application and, in turn, guarantee the stability of the operation. In conclusion, the factors contributing to inefficiency are enumerated.

One point brought out in the discussion of the paper relates to the danger of making too many changes. It is stated that if the manufacturer changes the truck model every year to conform with the annual style, he will not have a standardization program and his operating costs will increase. The problem of heavy traffic on roads is mentioned and the opinions are expressed that the development of roads must be carried forward on an economic basis and that no type of road should be saddled on the public for the benefit of any one class of users of that road. Further applications in line with saving human labor are cited, as well as examples of the use of multiple-wheel trucks and trailers.

FOR years the motor-vehicle served only as an instrument of transportation, merely replacing the horse-drawn vehicle and exceeding it only in load capacity and range of distribution. But many factors gradually forced a recognition of motor-vehicles as necessary adjuncts to business and a consideration of their value as effective instruments for speeding up and expanding all forms of business. Throughout this period of widespread and increasing use of motor-vehicles we have had a rapidly rising scale of wages in all forms of industry, and now the motor-vehicle is being called upon more than ever before to serve also as a labor-saving device. In fact, almost any form of its present application might be considered to be indirect labor-saving. The utilization of modern discoveries and the mounting of many machines, formerly used only as stationary units, on commercial-vehicle chassis have broadened the field, and we believe that present-day business will demand many other such developments. The groups interested in establishing and developing the motor-vehicle in business are the manufacturers thereof, the commercial organizations operating vehicles for their individual needs, the commercial operators supplying service for a variety of customers, and the railroads.

The manufacturers must be given full credit for the development of the vehicles to their present stage of dependability, and for their promotion work in bringing the commercial world to a realization of the value of the motor-vehicle in business. Their products are now so firmly established and so widely used that they have become one of the most important links in our chain of transportation facilities. We who are interested in the application of the motor-vehicle are deeply indebted to them, not only for our livelihood, but also for many of our material comforts.

Commercial Organizations Most Extensive Users

The commercial organizations operating vehicles for their individual needs should be credited for the most consistent and stabilized development in motor-vehicle applications. They own 82 per cent of the motor-vehicles used in this Country. They have both the resources for conducting experimental work and, usually, the facilities for determining the economies of their applications as compared with previous needs. The result is that motor-vehicles have a definitely proved value in having reduced the total cost of doing business.

For these organizations, motor-vehicles have become an advertising medium, an instrument for meeting competition, a means of expanding business and, in special applications, labor-saving devices. For example, the ice-cream industry has improved its distribution methods, using the motor-vehicle as its basic unit; formerly, the wooden containers with their iced products constituted the delivery units to all retail points. In the most modern distribution systems either the so-called "dry ice" or mechanically operated refrigerating units are used both on the vehicles and at retail points. This industry can therefore use lighter and faster vehicles for distribution and secure an increased productive range per vehicle.

Packing-houses are now using special body-equipment for quick interplant transportation of dressed products. Overhead rails hung from the roof of the

[1] M.S.A.E.—President, Motor Haulage Co., Inc., Brooklyn, N. Y.

vehicle enable the products to be transferred direct from plant rails to vehicle rails at the loading point and from vehicle rails to plant rails at unloading points. Many labor-saving applications have been made in the construction field, such as quick deliveries of materials through the use of container units and the mounting of shovels, excavators and road-building machinery on truck chassis. The early practice on some forms of concrete work was to deliver a load of sand, a load of stone, and a load of cement. Next came the delivery on one truck of all the ingredients in proper proportions direct to the mixer. Today concrete mixers are mounted on truck chassis, receive all the ingredients at a central plant, and deliver the concrete ready for use. Plaster is also being delivered to jobs ready for use. Milk, ink, syrups and many other liquid products are being delivered by motor-trucks equipped with tanks.

Many large corporations employ men to study the problem of the application of the motor-vehicle. The equipment used by public-service corporations for construction, installation and service furnishes excellent examples of the results of engineering study and application. A crew of five men, using a truck equipped with power-driven post-hole auger, winch and pole-raising derrick, can set more poles in one day than a crew of 12 men, using manpower alone, could set in several days. With this type of unit the average reduction in labor has been 66 2/3 per cent. With labor representing 90 per cent of construction costs, and vehicle operation less than 10 per cent of labor costs, these reductions more than justify the effort spent in the development of the equipment.

Problems of the Commercial Operators

Fundamentally, the problems of the commercial operators are different from those of the corporation operators. First, their adaptations of vehicles are made to serve many customers and, consequently, a variety of applications. This may seem a simple problem. It is, insofar as the mere operation of the vehicles is concerned; but, to compensate for the organization necessary to meet the customers' requirements intelligently is an entirely different problem, and no application of motor-vehicles, no matter how large or how small, can exist long without its supporting organization. Second, because of the comparative ease with which one can become an operator of motor-vehicles, they face an abnormal competition and, even though the rate of mortality in the business indicates the unstable nature of this competition, it nevertheless seems to be a continuous procession. The abnormal competition in this instance can be traced almost entirely to the lack of an adequate cost-system. In spite of these conditions, some commercial operators are today conducting well-established businesses on a profitable basis. Why? Because they are selling an intelligent service on the basis of cost. Further, because of their ability to absorb the seasonal equipment demands of their various customers, they are able to provide a service that is more economical than these customers could obtain by operating their own equipment. The commercial operators, however, own only 18 per cent of the commercial vehicles in this Country.

According to statistics of the National Automobile Chamber of Commerce, out of 531,628 commercial vehicles produced in 1925, the peak year for commercial production in the United States and Canada, 76,262 or 14.3 per cent were exported. In 1927, out of 487,653 vehicles produced, 125,185 or 25.4 per cent were exported. The total production decreased 8.3 per cent during this period, and exports increased 63 per cent. The total production during the first eight months of 1928 indicates an increase of 5.5 per cent over the same period of 1927, exports representing 27 per cent of the total or an increase of 12.8 per cent for the same period.

These figures indicate a very decided decrease in domestic absorption of commercial vehicles, either because of a market saturation or a decided trend in business in favor of a more economical service. Judging from our own experience, I am inclined to believe the latter is the cause for the reason that, in the last two years, we have received more unsolicited inquiries from the 82-per cent class than we were able to obtain by active solicitation in the two previous years and, in every instance in which we have taken over operations of any size, we have been able to make large reductions in equipment while still giving equal, if not better, service.

Varied Applications in Railroad Service

The railroads have become large and potential motor-vehicle buyers during the last few years. It has been rumored that the motor-vehicle forced them into the family, and it is apparent that the 18-per cent group started something. They moved freight from here to there most informally, establishing precedents which we like to believe have been responsible for much of the present efficiency in freight transportation. The 1927 N.A.C.C. statistics tell us that 59 railroads of the United States and Canada use motor-trucks, 47 for terminal operations, 13 for store-door delivery, and 17 to replace local freight-trains. Some of the companies making these applications in the United States, such as the Columbia Terminals Co. in St. Louis and the Cincinnati Motor Terminals Co., have given service of long duration and are well stabilized on a profitable basis. However, many other applications are still experiments from the cost point of view and, until the total cost of motor-vehicle applications can be more universally understood and intelligently presented, the true value of the service cannot be determined. This condition is as dangerous for the buyer as for the seller, because of the liability of establishing a practice with a rate structure that will neither guarantee stability of application nor tend to promote to the fullest extent the economic coordination of motor-vehicles with our established rail facilities.

Uniform Cost-Accounting Essential

The problem of acquiring a better knowledge of the cost of doing business may not seem very serious, particularly as it seems to concern directly such a small percentage of the vehicle operators; but, in my estimation, present competition in all forms of business makes this problem equally serious for all users of commercial vehicles. It is as important for the commercial organization to know the real cost of owning and operating vehicles as it is for the commercial operator, yet it is surprising how little consideration this subject is given. During our periodic invasions into the 82-per cent class of vehicle owners and operators, we have found many peculiar determinations and adaptations of costs. One nationally known organization which operates its own vehicles has no odometers on its vehicles and the drivers

estimate the mileage; yet its operation cost is reduced to a cost-per-ton-mile basis, working to four decimal places. Another large organization spent three months trying to learn the cost per 100 lb. of its commodity transportation. Figures obtained from the several departments were reduced to a cost per truck per day and, further, to a cost-per-hour basis. The drivers' cards, which were the basis for this distribution to the various classes of work, read "time left plant" and "time returned." The clerks, in applying hourly costs, failed to account for the time spent at the plant. The result was that less than 90 per cent of the actual cost was used to determine unit costs. Another organization charges no expense, other than garage expenses, drivers' wages and depreciation, against vehicle operation. Ordinary clerical expense is charged to general-office expense, dispatching and routing clerks' time to the shipping department, and painting to advertising.

Cost System Should Present Complete Picture

Considering the entire field of the application of commercial vehicles, there is to me no problem more important to all users of these vehicles than that of an adequate cost-system. It should present a true picture of the total cost of owning and operating motor-vehicles, be sufficiently uniform to serve all users, make possible a true comparison of at least some phases of operation, and allow the proper application of costs to individual jobs for the commercial operator.

We have developed a cost-accounting system for our business and have been using it for the last seven years. I firmly believe that it can be adapted to any kind of business. It is not only a part of our monthly financial statement, but also permits of a profit-and-loss determination on the individual accounts for the same period. In principle, it separates from the basic costs of the business, that is, those costs common to all operations, the costs which are peculiar to the individual jobs, and which we term direct operating costs. Lack of facilities for isolating and controlling these factors can make or break any business, and to this we attribute all the difficulties encountered in establishing the value of a commercial application. For example, direct operating costs represent 43.5 per cent of our total cost of doing business and, without the facilities provided by our cost system, we should not be able to determine whether we were having red-ink or black-ink prosperity on a given job.

It has always been my contention that the economic value of motor-vehicle application must depend upon its ability to stand upon its own feet. I further believe that it is only through the proper and practical use of cost data that both the buyer and the seller can be brought to the mutual understanding which is necessary to establish this value and, in turn, guarantee the stability of the operation.

Factors Contributing to Inefficiency

The commercial vehicle is primarily a production machine; but if in the process of its manufacture the several production machines supplying its component parts were subjected to the delays and restrictions to which the vehicle itself is subjected when attempting to produce, the motor-vehicle dollar of today would probably be worth about 7 cents. While these conditions influencing production are beyond the direct control of the owners and operators of commercial vehicles, it seems to me that their influence upon the cost of production is of sufficient importance to demand the serious consideration of all classes of business.

Regarding legislative restrictions, business demands forced the development of the motor-vehicle to its present load-capacities, yet in some States heavy vehicles are entirely eliminated. In other States it is not possible to carry even the rated-capacity load; consequently, there is a trend toward the lighter-capacity vehicles of higher speed. Contrast this tendency with the development of our railroad systems. It seems to me that, in the present state of development of improved highways, safety and economy are being sacrificed for political expediency. I do not advocate gross overloading of equipment, but I feel that, in the interest of economy, road design and legislation should follow the demands of business rather than that legislation should influence the trend of design and increase congestion.

As to other restrictions, upon examining a comparatively new building which one of our customers had in mind for use as a distributing center, we found that the clearance between columns in front of the loading platform, said to be sufficient for two trucks, was not equal to twice the maximum body width permitted by law. The headroom at the entrance was not sufficient to permit the use of semi-trailers, except those having low racks. The architects responsible for this building unknowingly subjected the tenants to a handicap which must be reflected in the tenants' delivery costs.

Delays caused by the general problem of congestion constitute the greatest factor influencing production costs in city districts. It is virtually impossible to estimate the effect of street congestion on costs, other than on a production basis. Indiscriminate parking, one-way streets and unbalanced traffic-control systems all have their effect. In downtown Manhattan our drivers have often been unable to travel a full block on crosstown traffic between intervals of traffic-control lights. Think of what this means in the day's work in trying to make a series of deliveries on one-way streets or to east-side and west-side piers. Poor receiving conditions are frequently responsible for many delays of from one to two hours.

In the general shipping and transfer of freight within the Port of New York, pier conditions are responsible for a high percentage of the costs. Unusual congestion seems to be accepted as a matter of course, and lines of vehicles waiting at piers furnish the basis for many drivers' alibis. Worst of all, the actual operators of these piers do not assume any responsibility for the movement of goods from piers to customers' vehicles, and allow public loaders to regulate pier capacities and impose undue costs upon the shippers or receivers of freight. Because of limiting working hours, very little delay suffices to eliminate one trip from the day's work. When translated into cost per 100 lb., this may mean an increase ranging from 10 to 30 per cent.

Summary

I have endeavored to give some idea of the conditions that seem to prevail throughout the field of motor-vehicle application. Some of the needs of the industry, as seen from the point of view of the commercial operator, are pointed out. Within the industry there are many profitable as well as economical operations; but, if the industry as a whole is to profit by the mistakes of others, some common ground is necessary on which

an intelligent comparison of accomplishments can be made. A uniform cost-accounting system should provide this medium.

Many conditions outside the industry should be the direct concern of all business if it does not wish to be faced continuously with a transportation-service cost that will increase in direct proportion to the curtailment of the production of the motor-vehicles in the service. Whether the curtailment be the result of legislation, congestion or other conditions, the conditions present problems to which business should give a greater cooperative effort if it desires to assure the economies that can be obtained from a realization of the full productive capacity of commercial motor-vehicles.

My hope is that the Society will continue its constructive efforts in endeavoring to take a larger part in the study and solving of all the problems that are so vital to the welfare of the machines of the automotive industry's creation.

THE DISCUSSION

F. C. HORNER[2]:—We have come to a phase of motor transport which is not simply one of truck operation or motorcoach operation; it is one which constitutes a transportation problem. We are vitally concerned with the application of this new tool, the motor-vehicle, to the requirements of today, and the sooner we reach that conclusion and face the music the more progress we shall make. That probably is even more true from the viewpoint of operators of the railroads and the electric railways of the Country than it is of the motor-transport operators. The sooner these realize that they are in the transportation business and must make use of the tool that will produce the best results, the sooner will they solve their problems. In the large automobile factories, after an analysis shows that a real saving can be made, a tool that is not producing the best results or giving as good service as some other tool is replaced with a new tool.

I have always felt that the manufacturers of motor-trucks have not given sufficient attention to the requirements of the user, although great improvement has been noted in that respect in the last several years.

Meeting Changing Demands

A. J. SCAIFE[3]:—There is a difference between the manufacture of motor-trucks and of passenger-cars. About 24,000,000 passenger-cars and 3,000,000 motor-trucks are operating in this Country today. The operators of passenger-cars do not buy them in fleets. Passenger-cars are used in connection with business, but even then the operators of the cars used for this purpose are the first to complain if the manufacturer makes too many changes. As to development, if the manufacturer changes the truck model every year to conform with the annual style, he will not have a standardization program and his operating costs will increase.

We are confronted with the very difficult problems of trying to make a motor-vehicle which meets changing demands, and it would be foolish for me or for anyone to say that the demands are not changing. But it is extremely difficult to meet the changing demands with regard to the same vehicle without changing the design. Therefore, some of the motor-truck engineers try to make the necessary changes, whatever they may be, so that it is possible to incorporate them in all the vehicles of that type which were built during the last four to six years. Frequently we are prevented from making some desired change because of that fact. It is easy for any manufacturer to begin today to design a line of vehicles, if he does not need to consider vehicles of that type which already are operating and must be serviced.

Another point is that, because the market for motor-trucks is not so large as that for passenger-cars, it is not profitable to change the models frequently. The motor-truck manufacturer is not in the business for his health; he tries to make as much money as possible from the vehicles he builds. He maintains a certain design and sells as many vehicles of that design as he can, just as does the manufacturer of passenger-cars. The difference is that the builder of passenger-cars can sell a certain design of car in quantity and dispose of it in say a year. But if the motor-truck manufacturer tried to dispose of 100,000 trucks, it would require several years to accomplish it.

G. P. ANDERSON[4]:—The companies with which I am connected do not build the trucks of large capacity that Mr. Banks mentioned in connection with the handicaps under which these large vehicles operate, such as congested traffic, dimensional limitations of buildings and areaways and the restrictions put upon them by various legislative bodies regarding their capacity. These handicaps are unfortunate because, in many instances, a large-capacity vehicle may be more economical than a smaller one for a particular job. On the contrary, legislation must be for the benefit of all people. Naturally, roadways are built more for the use of passenger traffic than for heavy freight-traffic, and it would be uneconomic to require standards of road construction for the great majority of the highways which would permit the passage of these larger freight-vehicles without damage to the road.

Heavy Transport Benefits All

M. C. HORINE[5]:—I agree with Mr. Anderson that the development of roads must be carried forward on an economic basis and that no type of road should be saddled on the public for the benefit of any one class of users of that road. As Mr. Banks indicated, too much consideration has been given the passenger-cars and not enough to the motor-truck, in connection with highway design. A common error of thought along these lines is that the only beneficiary of the operation of large-capacity trucks is the operator of those trucks. The purpose of large-capacity trucks is solely the trans-

[2] M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

[3] M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

[4] M.S.A.E.—Director of sales engineering, Dodge Bros. Corp., Detroit.

[5] M.S.A.E.—Manager, sales promotion department, International Motor Co., Long Island City, N. Y.

portation of needed commodities at the lowest cost per ton-mile. Economy of the transportation of the world's goods is reflected in lower living costs for all.

I believe that we are on the verge of a compromise between the large-capacity truck which requires a road built at an excessive cost per mile and the light truck requiring only a light-duty road but which costs an excessive amount per ton-mile in cases where bulk loads are to be hauled. Multi-wheel pneumatic-tired trucks that can haul large loads on relatively light-duty roads are likely in the near future, and they will confine the problems of capacity to bridges.

E. W. JAHN[6]:—Our company formerly pulled cable into the ducts by using a hand-power winch, which sometimes necessitated using a crew of 13 men. Now that we use power-driven winches, our crews are about half that size. For the setting of poles, our heavy-duty trucks are equipped with a power winch and a collapsible reel. Recently, one crew bored 50 holes in sandy soil and set the poles in one day. To take care of new districts, we have added about six 3½-ton trucks equipped with pneumatic tires. We have used pumps mounted on the front end of our light-duty trucks, but they have not been entirely satisfactory, so we use pumps mounted on the running boards and driven from the power take-off.

[6] M.S.A.E.—Superintendent, transportation department, Consolidated Gas, Electric Light & Power Co., Baltimore.

[7] M.S.A.E.—Superintendent, transportation department, San Francisco division, Pacific Gas & Electric Co., San Francisco.

Multiple-Wheel Trucks and Trailers

E. C. WOOD[7]:—For use in long-haul work, the six-wheel truck and the eight-wheel trailers have been utilized on the Pacific Coast for hauling gasoline, one tank being mounted on the truck and the other on the trailer. The truck weighs 33,750 lb. and the trailer 31,000 lb. A fleet of eight of these vehicles is in service and the maximum speed is about 35 m.p.h. One of these units has traveled 31,000 miles and its total repair bill for that distance was $74. Its total mechanical expense was $162. It travels from 250 to 275 miles per day, and the average life of the tires probably will be 50,000 miles.

MR. SCAIFE:—There is a growing tendency for increased speed and heavier loads. Motor-vehicles are called upon at present to carry gross weights up to 60,000 lb. at speeds up to 35 and 40 m.p.h. Without question, we shall have 6, 10 and 12-wheel units, and we shall have to increase the speed of these units.

Commercial Air-Law Unification

THE Third International Air Congress, held in Brussels early in October, 1925, adopted a resolution that the next meeting of the International Conference in Paris should consider the advantages that would be afforded by the unification of private international air-law, and to decide on the method of study and organization that would best further this unification. This resolution finally emphasized the needs of business men and of lawyers with regard to air travel. It received earnest consideration at the Paris conference at the end of October, 1925, which brought together the delegates of 43 nations. The Paris Conference ended with the adoption of a final protocol which contained, first, a draft of the "Convention regarding the reliability of the carrier in international transportation by aircraft." In addition, the Conference adopted a motion, which it recommended to the favorable consideration of the governments represented, to effect the appointment of a special committee of juridical experts to undertake the methodical, complete and, in a sense, permanent study of the important questions.

It may be said that this Conference marked the beginning of the realization of the International Air Code. The success of the Conference decided the various governments to welcome the motion presented, and in May, 1926, the International Technical Committee of Aeronautical Juridical Experts met in Paris, when its first session was attended by official experts of 28 states.

At its sessions in Paris, in April, 1927, and Madrid, in May, 1928, the Committee completed a tentative project of convention dealing with air-shipping documents and with the liability of carriers in international air transportation. This project is to be considered by the Second International Conference on Private Air-Law, which is to meet in Warsaw, Sept. 29, 1929. If, as may be expected, it is accepted by the governments, the first International Charter of Commercial Aviation will be established.

The work which is being carried on and has been partially completed by the commissions of the Committee of Juridical Experts is as follows:

(1) Tentative draft of convention on registration of ownership and of mortgaging of aircraft
(2) Tentative draft of convention on damages caused to persons and property on land
(3) Tentative draft of convention on air insurance
(4) Tentative draft of convention on the juridical condition of the commander of the aircraft

Following the adoption of a final text, these drafts will be placed before future International Conferences for consideration.

The activity shown by the Technical Committee, the importance of the juridical work already achieved, and the originality and importance of the task show why such a large number of states immediately adhered to this organization.

At this time, after the first flights of the Wright brothers, the splendid performances by Charles A. Lindbergh, Richard Byrd and other great pioneers who crossed the Atlantic have shown that air travel is destined to bring closer together the peoples and the continents, it is necessary—and tomorrow it will be indispensable—for business men that a uniform juridicial system shall govern all over the world the aircraft, its owners, its operator, its captain and crew, as well as the passenger, the bill of lading and the cargo.

Nothing will serve better the development of commercial aviation than the unification of laws connected with it. And besides aviation, few achievements will be more useful to all nations of the world, to their mutual understanding, their friendly and trustful cooperation, than the achievement of a common law carried on the wings with which mankind has conquered the air. This is why the work of the International Technical Committee of Air Juridical Experts deserves to be known, supported and helped by all men of peace and good-will.—From address by Edward Sudre, at the International Civil Aeronautics Conference, City of Washington, December, 1928.

Automotive Research

Gyro-Accelerometer Analysis of Riding-Quality

By MERRITT L. FOX[1] AND THOMAS J. CARMICHAEL[2]

This paper describes the construction, theory and some uses of the Gyro-Accelerometer, an instrument capable of recording angular velocity, angular acceleration and the total angle turned. The design and development of this instrument came as the result of research into the riding-qualities of automobiles conducted by the Department of Mechanical Engineering at the State University of Iowa. These investigations demonstrated the necessity of measuring angular motions under road conditions which was impossible with available equipment. The instrument furnishes an analysis of angular movements whereby the characteristics of the springs and shock-absorbers can be so matched as to give the body the lowest values of angular acceleration and therefore the best riding-quality.

The description of the Gyro-Accelerometer and some of its applications should serve as the basis for a better understanding and appreciation of the results of riding-qualities tests and personal-opinion curves which will be the subject of a paper to be presented by Professor Fox at the Summer Meeting, Saranac Lake, June 25 to 28.

THE Department of Mechanical Engineering at the State University of Iowa has conducted investigations and tests on automobile engines and on complete automobile chassis for several years. Engine and chassis design have been rapidly developed but little change has been made until recently in methods of suspension and resulting riding-quality. When this work was undertaken, little analytical study had been made of the relative effects of the factors contributing to the riding-qualities of a car. Apparently many factors contribute either directly or indirectly to discomforts of riding and many poor-riding chassis are able to compete because of the extra-deep seat cushions. Any correction of riding-quality should, however, be made to the chassis.

In the preliminary study of this problem in the laboratory, the front or rear wheels of the car to be studied were held on the wide-rimmed wheels of the dynamometer testing outfit. Wooden blocks were fastened to these wheels to simulate bumps in the road, and runs were made at different speeds with the car under its own power, or by power from the electric dynamometer, thus simulating the condition of both driving and coasting. By markers attached to the car axles and frame, the resulting motions of these parts were recorded when the car passed over the bumps.

Road tests were also conducted using a recorder operating on the floating weight or seismographic principle. This instrument was similar to that described[3] in THE JOURNAL by Dr. Benjamin Liebowitz[4].

Limitations of Existing Instruments

The results of both laboratory and road tests were based on the vertical movements of certain points on the car of which records were made. It is apparent that these vertical movements are largely components of angular movements of the automobile resulting from the front wheels passing over an obstruction before the rear wheels, which causes an oscillatory movement of the body to be set up about a variable center usually situated near the back of the front seat. From these results it was evident that an instrument which would measure angular movements would have many advantages over one measuring vertical components, especially in road tests when the front wheels must pass over the bump first. To build an instrument making use of the precessional property of the gyroscope, as reviewed below, seemed practical. The construction and calibration of this instrument, known as the Gyro-Accelerometer, are herein described.

Precessional Property of Gyroscope

If a heavy rimmed wheel is revolving about its own axis and a torque is applied to rotate the wheel about an axis perpendicular to that axis, the wheel will tend to precess, or turn as a whole, in a direction which, if continued for 90 deg., will bring the wheel axle parallel to the torque axis, and the rotation of the wheel will be in the same direction as that of the applied torque.

In Fig. 1(*A*), *OX* is the spin axis, *OY* is the torque axis and *OZ*, mutually perpendicular to these, is the precessional axis. If I is the moment of inertia of the rotating wheel with respect to the axis of rotation and μ is its angular velocity, its angular momentum is their product $I\mu$, represented by the vector *ON* in Fig. 1(*B*). This vector points to the left if the rotation is clockwise when viewed from the right end. If a torque Pa is applied to the gimbal-ring which would tend to turn the spinning wheel about the torque axis *OY* in a clockwise direction viewed from above, this torque will have an angular impulse $Pa\ dt$ in dt time, and will produce an equal change in the angular momentum about axis *OY*. This is represented by vector *OL* in Fig. 1(*B*). The resultant angular momentum of the body is represented in amount and direction by the resultant *OP*

[1] Assistant professor of mechanical engineering, State University of Iowa, Iowa City, Iowa.

[2] Laboratory assistant, department of mechanical engineering, State University of Iowa, Iowa City, Iowa.

[3] See THE JOURNAL, January, 1920, p. 17.

[4] M.S.A.E.—New York City.

of the two angular-momentum vectors, ON and OL, at an angle $d\phi$ with the vector ON. This resultant OP is the new axis of spin and, in order that it shall become so, the body must rotate about axis OZ, the direction being counterclockwise viewed from the Z side of the wheel. This motion about OZ is called precession, and OZ is the precessional axis.

In Fig. 1 $OL = NP$, and in angular measure

$$\frac{OL}{ON} = \frac{NP}{ON} = \tan d\phi = d\phi$$

$$d\Phi = \frac{OL}{ON}\,\frac{Pa\,dt}{I\mu}$$

$$\frac{d\phi}{dt} = \frac{Pa}{I\mu}$$

But $\frac{d\phi}{dt} = \Omega$, the angular velocity of precession about axis OZ, then

$$\Omega = \frac{Pa}{I\mu}$$

or

$$Pa = I\mu\Omega$$

in which

P = Force either causing or resulting from precession of the gyroscopic wheel
a = Moment arm of P about the torque axis
Ω = Angular velocity of precession measured in radians per second
I = Moment of inertia of rotating wheel
μ = Angular velocity of rotating wheel.

Elementary Theory Applied to Gyro-Accelerometer

In the equation $Pa = I\mu\Omega$ the moment arm a, of the force, and I, the moment of inertia, represent constant properties of the constructed instrument. By keeping

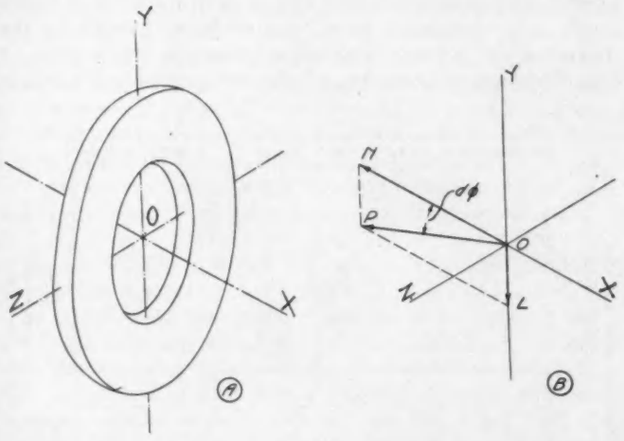


FIG. 1—DIAGRAM OF AXES AND FORCES IN GYROSCOPE
OX Is the Spin Axis, OY the Force Axis, and OZ the Processional Axis

μ, the angular velocity of the rotating wheel, constant at the time readings are being made, the above equation states that the force P, due to precession, is directly proportional to the angular velocity, Ω, of precession. Thus, if a revolving gyroscopic wheel is caused to swing through an angle about its precessional axis with a velocity Ω, a proportional force P will be set up about the torque axis. It will be noted that this relationship is not affected by linear motion and that the force P gives a direct means of measuring the angular velocity[5].

[5] Compared with The Theory and Practice of Mechanics, by S. E. Slocum; also Applied Mechanics, by A. P. Poorman.

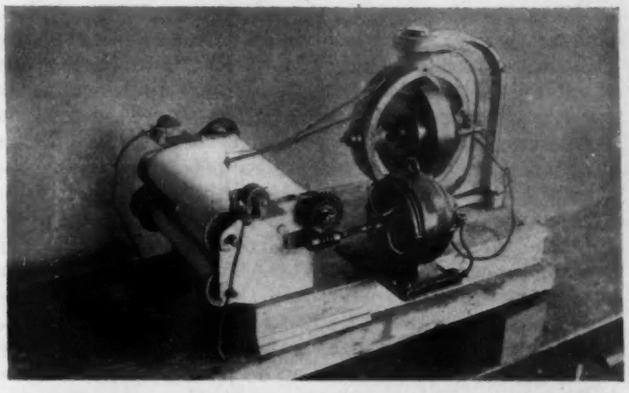


FIG. 2—VIEW OF GYRO-ACCELEROMETER SHOWING CONSTANT-SPEED MOTOR DRIVE TO CONTINUOUS PAPER RECORD

Description of the Gyro-Accelerometer

The instrument, as shown in Figs. 2 and 3, was constructed at the engineering laboratory of the University. It consists, briefly, of a wheel with its spin axis held in a gimbal-ring supported by a bracket attached to the base. The gimbal-ring is restrained from turning by a spring attached between it and the bracket. A pencil marker is fastened by an arm to the gimbal-ring and records on a continuous paper record the amount it swings. At the lower end of the gimbal-ring a pulley and steel belt operate a dampening device located in the base of the instrument.

Taking the construction more in detail, it will be noted that the wheel has a relatively heavy rim and is revolved at nearly constant speed by an electric motor, the armature of which forms a part of the revolving wheel. The field of this motor is stationary and attached to the shaft about which the wheel revolves. This shaft is fastened in the gimbal-ring so as to be adjustable, thus allowing the location of the wheel to be altered axially. Both the wheel and the gimbal-ring turn on adjustable ball bearings. The gimbal or torque axis shown as OY in Fig. 1(A) is perpendicular to the spin axis OX of the gyroscopic wheel and intersects it in a plane containing its radius of gyration.

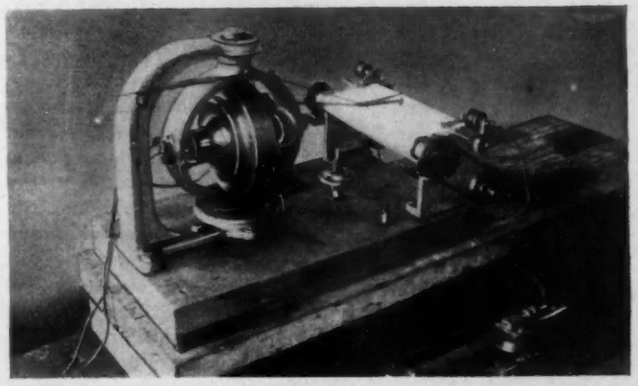


FIG. 3—VIEW SHOWING CALIBRATING SPRING BETWEEN GIMBAL-RING AND SUPPORTING ARM
The Angle Turned by the Gimbal-Ring Is Controlled by the Stiffness of the Calibrating Spring

When the instrument is turned about the precessional axis OZ, which is perpendicular to both the spin and torque axes, the resulting force P, in Fig. 1(B), about the torque axis is proportional to the angular velocity of precession and is resisted by a spring the deflection of which is proportional to this force. This spring is fastened between the gimbal-ring and an arm attached to the supporting bracket, as seen in Fig. 3. The length determines the zero position of the gimbal-ring, the spring being compressed when on one side and extended when on the other side of this position. An adjusting screw is provided on the bracket end of the spring to bring the gimbal-ring to the zero position. Since this calibrating spring between the gimbal-ring and the bracket is attached so as to be at right angles to its operating arm when in zero position, its deflection is proportional to the sine of the angle turned by the gimbal.

The pencil recorder, carried by an arm also attached to the gimbal, records its angular movement on the arc

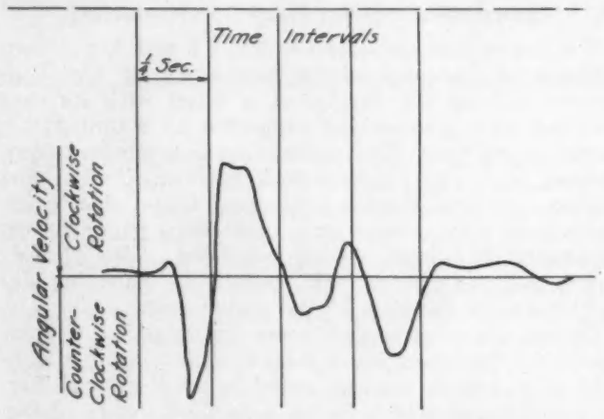


FIG. 4—TYPICAL CURVE FROM PORTION OF A RECORD
Taken in a Road Test When a Car Was Driven Over a Standard Bump at a Speed of 25 M.P.H.

of a circle of radius equal to the distance of the pencil from the gimbal axis. Since, with this construction, the deflection of the spring is proportional to the sine of the angle turned by the gimbal-ring, the height on the record at right angles to the zero line is a measure of the deflection of the spring and therefore is proportional to the angular velocity of the instrument about the precessional axis.

Just above the base the gimbal carries a grooved pulley to which is attached a piano-wire belt which drives directly a second pulley attached to a shaft extending through the base and operating a vane in an oil cylinder located in the base. The purpose of this vane is to absorb and dissipate the energy stored in the spring in excess of the amount necessary to bring the gimbal back to the zero position. The velocity of the vane is thus proportional to that of the gimbal-ring; its velocity and the viscosity of the oil must be adjusted so that when the gimbal is deflected and released it will return exactly to the zero position.

The paper record consists of a continuous roll of paper 7 in. wide which is drawn under the recording pencil by a pair of wringer-rolls operated by a constant-speed motor. The paper is fed off one roll and reeled on to another; the length of the record thus depends only on the size of the rolls. As it is essential that the

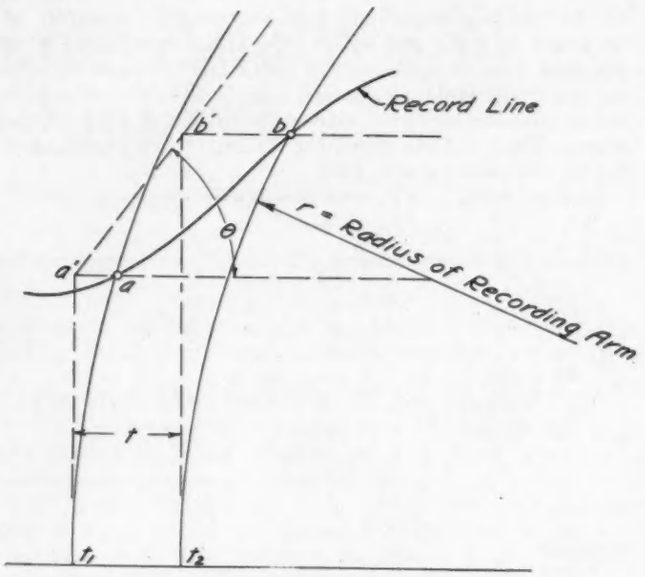


FIG. 5—METHOD OF CORRECTING PAPER RECORD
Location of Points a and b on the Record Must Be Corrected to Positions a' and b' Because the Recording Arm Swings in the Arc of a Circle. Acceleration Is Then Represented by the Slope of the Line Connecting a' and b'

paper record should travel at uniform speed, the instrument had an electrically operated marker attached so that a check could be maintained on the distance the paper traveled in equal time-intervals during tests.

On the record produced by the instrument, a small portion of one being shown in Fig. 4, the side of the zero position to which the pencil moves depends both on the direction of rotation of the gyroscopic wheel and on the direction of rotation of the instrument as a whole

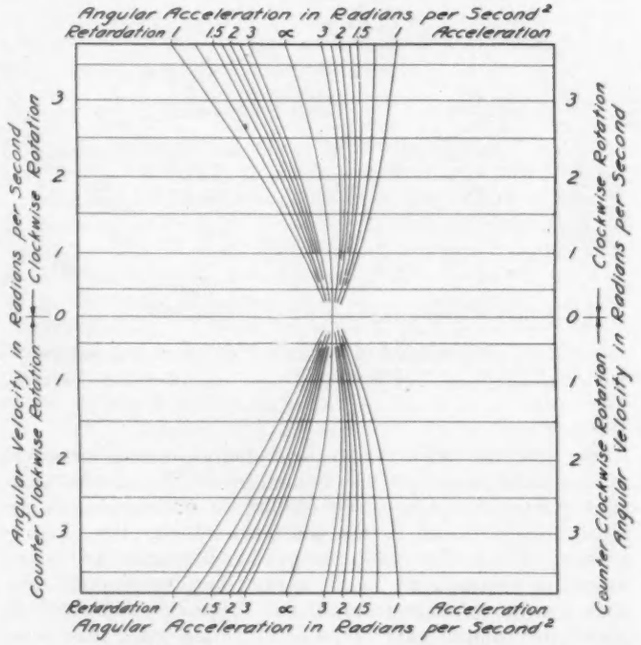

Angular Acceleration in Radians per Second²
Retardation 1 1.5 2 3 ∞ 3 2 1.5 1 Acceleration
Angular Velocity in Radians per Second
Counter Clockwise Rotation — Clockwise Rotation
3
2
1
0
Retardation 1 1.5 2 3 ∞ 3 2 1.5 1 Acceleration
Angular Acceleration in Radians per Second²

FIG. 6—TRANSPARENT CELLULOID SCALE TO BE PLACED OVER RECORD TO AID IN READING VALUES OF ANGULAR VELOCITY AND ACCELERATION

about its precessional axis. In our instrument the wheel revolves away from the observer when viewed from the side which does not have the calibrated spring (Fig. 2). In this position the record end of the instrument is toward the left. When the instrument is turned in a counterclockwise direction, the pencil moves above the zero line, and when revolved in a clockwise direction the pencil moves below the zero line.

Application to Measurements of Acceleration

As shown in Fig. 5, if a and b are two points on the record, the angular velocities are measured by A_a and V_b, the heights of these points above the zero line. Because the recording pencil swings through an arc of radius r, the corrected horizontal positions along the record of these points are given by a' and b'. These are obtained by passing arcs of radius r through a and b, and erecting tangents to these arcs at their points of intersection with zero and locating a' and b' on these tangents at the same height above zero as a and b. The horizontal distance t_1t_2 between these points represents time, therefore the time required for a change in velocity from a to b is represented by distance t. Acceleration, being equal to change in velocity divided by time required for that change, may be expressed by $\frac{V_b - V_a}{t}$. On the figure this is equal to tangent of angle θ and is represented by the slope of the line through a' b'.

In order to use the recorder in practical testing, a transparent scale, as shown in Fig. 6, was prepared. On this scale the height of the horizontal rulings corresponds to values of angular velocities found on the calibration curve. The curve marked α is the arc of a circle of radius equal to that of the recorder arm. In preparing the scale of angular acceleration, horizontal distances were taken on the lines representing angular velocity corresponding to the interval of time required for the rate of change in angular velocity to equal the required angular acceleration and points plotted at these values. Curves were drawn through points of equal value and ruled on a transparent sheet of celluloid. By placing this scale over the record from the instrument, the height can be read as angular velocity, and slope as angular acceleration.

The instrument also gives a means of measuring the total angle through which it is turned about its precessional axis. Since the distance of the record above or below the zero line represents angular velocity and the horizontal distance is a measure of the time during which the velocity continued, the product is a measure of the total angle turned. This angle is represented on the record by the area inclosed between the angular-velocity and the zero lines. It follows that, if the instrument is revolved through several angles and returned to its original position, the areas above and below the zero line will be equal. The values of the areas are easily determined by the use of a planimeter.

Calibration of the Instrument

In order to calibrate the recorder, it was fastened to a tilting plank hinged at one end and given a reciprocating angular movement which was varied in both amplitude and frequency by the apparatus shown in Fig. 7. This consists of a slotted cross-head operated by a disc-crank driven by an electric motor through a variable-speed transmission. In this apparatus the magnitude of the angle of oscillation of the tilting table is altered by changing the length of the crank-arm. The face of the disc-crank is drilled and tapped to receive the crankpin so the length of stroke may be changed by quarter-inch steps. The velocity of the drive, and thus the frequency of oscillation, may be altered by turning a handwheel on the variable-speed drive.

In making readings of angular movements of the car body, the same amplitude and frequency are seldom repeated in succession; also, a calibration curve taken with repeated frequency and amplitude gives no test of the damping device. It was therefore necessary to compare

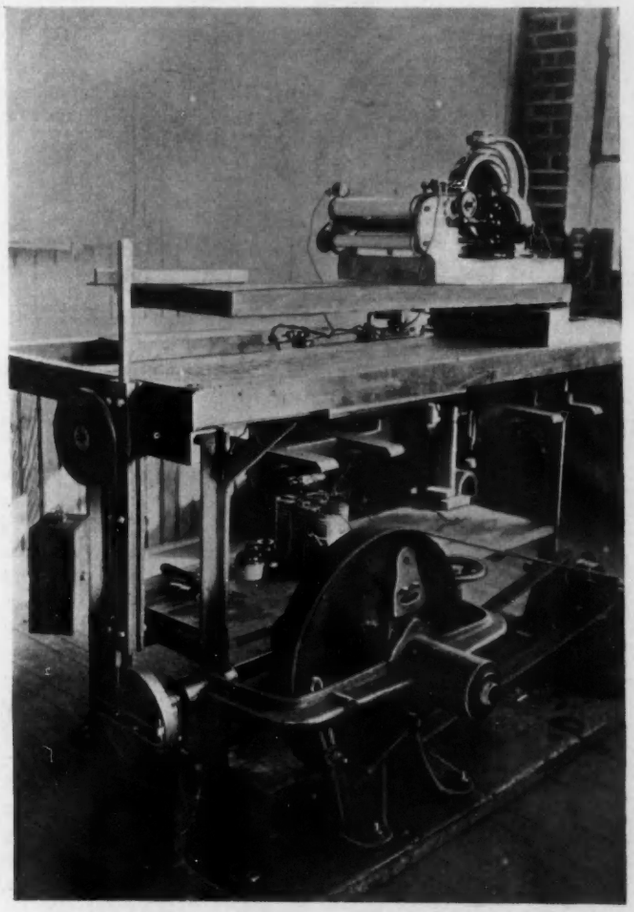


FIG. 7—CALIBRATING TABLE FOR GYRO-ACCELEROMETER
Angular Motion Is Given to the Instrument by a Hinged Plank on Which It Is Mounted. Frequency Is Varied by a Friction Drive, and Amplitude Is Varied by Change in the Position of a Pin in the Face of the Disc-Crank

readings with a varying frequency. To do this, a piece of solid rubber was placed under the tilting board, which suddenly arrested its movement at the lower portion of the travel.

Knowing the length of the tilting board from the driving end to the hinge, and both the velocity and amplitude of the drive, the angular velocity imparted to the instrument is calculated as given in Table 1.

Measurements were made of the pencil movements from zero position on the record for these values of angular velocity and a calibration curve was constructed

TABLE 1—READINGS FOR CALIBRATION CURVE
(Radius of tilting table = 42 in.)

Frequency of Crank, R.P.M.	Radius of Crank, Inches	Maximum Velocity of Crosshead, In. per Sec.	Height on Record, Inches	Angular Velocity, Radians per Sec.
73	2	15.1	3.25	0.359
44	2	9.2	1.90	0.219
32	2	6.6	1.40	0.157
70	1¾	12.7	3.02	0.302
55	1¾	10.1	2.15	0.240
34	1¾	6.0	1.20	0.143
72	1½	11.2	2.40	0.267
48	1½	7.5	1.55	0.179
33	1½	5.1	1.00	0.121
85	1¼	11.1	2.37	0.264
62	1¼	8.1	1.70	0.193
42	1¼	5.5	1.12	0.131
87	1¼	9.1	1.90	0.216
62	1	6.7	1.40	0.160
52	1	5.4	1.07	0.128
108	¾	8.5	1.76	0.202
86	¾	6.7	1.40	0.160
50	¾	3.9	0.75	0.093
104	½	5.5	1.10	0.131
94	½	4.9	0.95	0.117
72	½	3.8	0.75	0.090
126	¼	3.2	0.45	0.076
99	¼	2.6	0.35	0.062
82	¼	2.1	0.25	0.050

as in Fig. 8. It will be noted that the calibration curve is a straight line for the range of the instrument. This range depends on the characteristic of the spring controlling the movements of the gimbal-ring, and the range may be changed by using different springs. When the spring is changed it will be necessary also to adjust the energy-absorbing device so that the recording pencil will be dead beat to zero position. As constructed, the gimbal-ring has mass and is controlled by the spring, therefore becoming an oscillating pendulum that has a period of oscillation which must not fall near the same frequency as measured by the instrument. By taking readings at higher frequencies, the period for the instrument at a frequency of 336 per minute was found at which readings varied somewhat from the curve. This is a higher frequency than was used in the tests; however, future instruments should be built with the lighter parts and higher speeds to extend the useful range.

In studying the riding-quality of a car, it is evident that the front seat often rides with greater ease than the rear seat. This is due to the center about which the car oscillates being located nearer the front than the rear seat. To increase the ease of riding, the factors

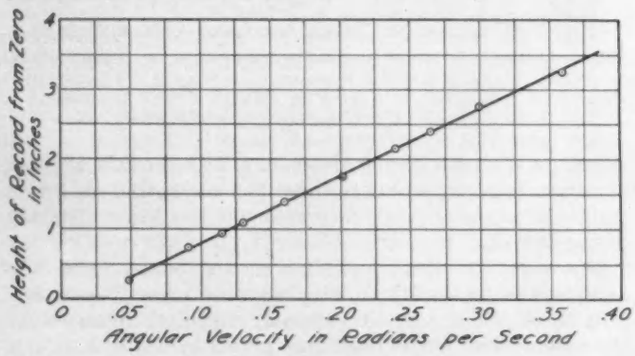


FIG. 8—CALIBRATION CURVE
Points of Differing Angular Velocity and Frequency Fall in a Straight Line

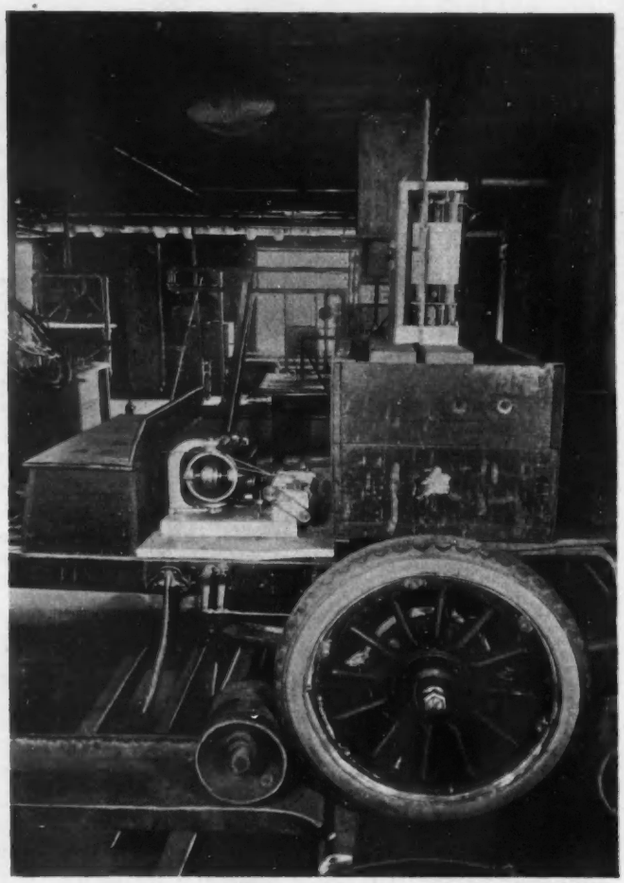


FIG. 9—GYRO-ACCELEROMETER AND DISPLACEMENT RECORDER MOUNTED ON A CHASSIS TO FIND THE VARIABLE CENTER OF OSCILLATION

influencing the location of the center should be studied. The record from the instrument furnishes a means of measuring the total angle turned by the car body, as described above. To find the center about which the car oscillates at any instant, it is necessary only to measure the vertical displacement at some point at the same time the angle turned is measured. Knowing the angle and a chord of this angle at some point in the car, it is a simple matter to locate graphically the vertex of the angle, which will be the center of oscillation.

Tests with Gyroscopic Recorder to Determine Oscillation Center

With the available laboratory equipment, the center about which a car chassis oscillated was located when bumps were passed over by one end of the car, the other end being blocked to the laboratory floor. The instrument was mounted on the chassis to be tested as shown in Fig. 9, and a marker arranged to read vertical displacement was mounted directly over the rear wheels. Magnetic time-markers were operated simultaneously on both the displacement and angular-velocity records. The tires were removed from the front wheels and the rims were fastened to a block so as not to be rigid laterally, which allowed the front springs their usual freedom.

The runs consisted of driving the large drums, upon

which the bump had been fastened and upon which the rear wheels of the chassis rested, at approximately 6 m.p.h. by means of the dynamometer acting as a motor. The chassis was in this manner allowed to coast over the bump and a record made of the oscillations set up by passing over it. The first run, results of which are shown in Fig. 10 (*A*), was made with no snubber or extra load added to the chassis. The springs were also oiled to give a maximum number of oscillations when passing over the bump. The second run, shown in Fig. 10 (*B*), was made with Gabriel snubbers attached to the rear axle only and no load added. The third run, shown by Fig. 10 (*C*), was made with no snubbers but with a load of 590 lb. added to the chassis at a point over the rear axle.

In Fig. 10 the numbered lines represent the consecutive positions of the car body at points of maximum rear-end displacement; the sequence of the numbers gives the order in which they occurred. The displacement recorder was mounted directly over the rear axle and its readings can be plotted at this position. The location of the front axle is indicated on the figures and the angle as calculated from the angular-velocity record was plotted on the figures. The location of the center at the instant when the chassis reached its maximum rear-end displacement is shown by the point at which the line indicating the chassis crosses the horizontal, these instantaneous centers being correspondingly numbered.

Similar tests should be conducted with bumps passing under both front and rear wheels; however, from these curves it will be seen that the front springs follow the action of the rear springs, and in road conditions it is reasonable to suppose that the rear springs follow reactions on the front, the center about which the car oscillates thus having a wide range of travel. The addition of the snubbers to the rear axle changed the location of the first center from about the middle of the chassis to a position well in front of the front wheels; the angle was also diminished and consequently the angular acceleration of the body reaction. In Fig. 10 (*C*) the addition of weight has also changed the location of the centers; however, it is interesting to note that the relative position of the first and second centers has been reversed from that in the first two classes.

The determination of the location of the centers about which a car oscillates when it passes over obstructions in the road opens a field of investigation in which little has been accomplished. If the car be designed so that a large part of the weight is at a considerable distance from this center, the radius of gyration is large and the car will require a relatively large energy-absorbing device to dampen oscillation. Whereas, a car of the same weight but with the weight concentrated close to the oscillating center would require a much smaller absorbing device. At present the appearance of the car receives first consideration and the engineer must place the mechanical parts where usage and popular taste

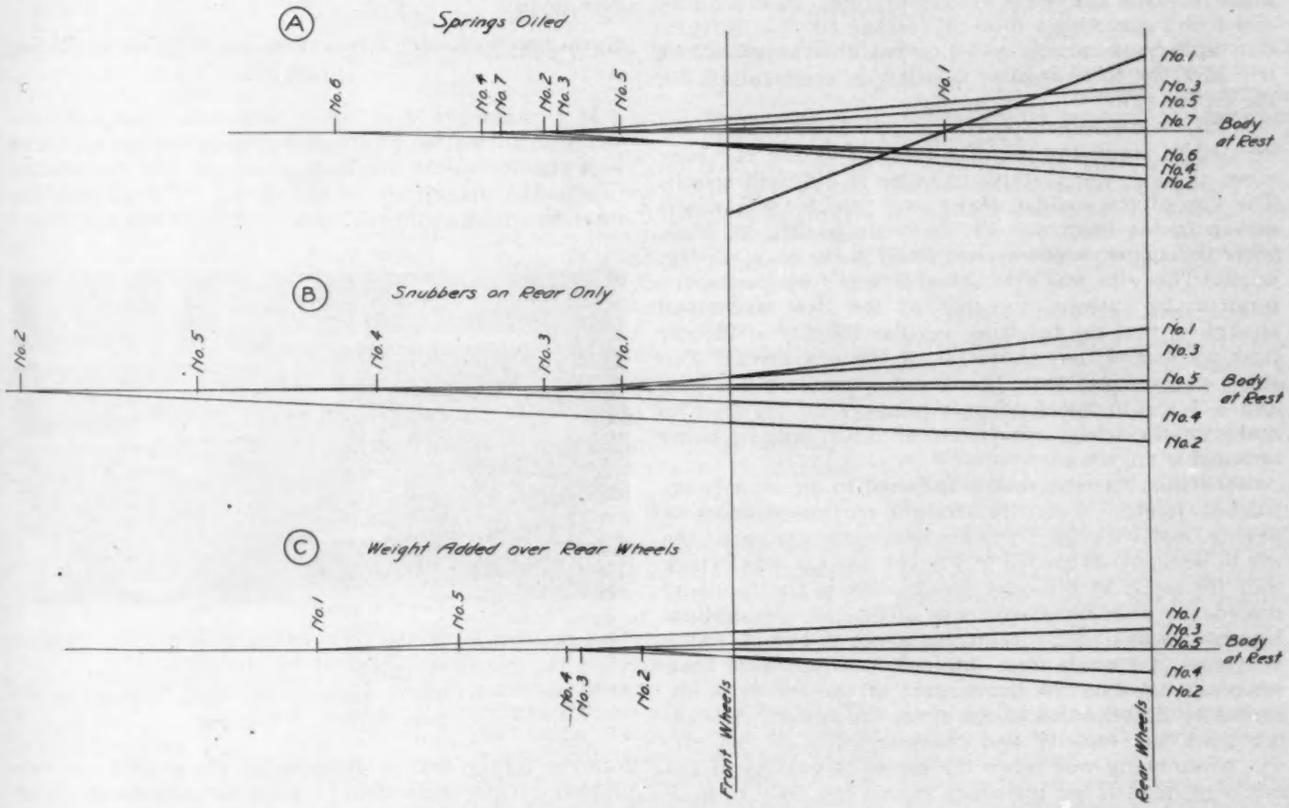


FIG. 10—RESULTS OF TEST RUNS IN THE LABORATORY, SHOWING LOCATION OF THE VARIABLE CENTER OF OSCILLATION
Rotating Drums in the Floor Passed Bumps Under the Rear Wheels Only, at a Speed of 6 M.P.H. The Numbered Heavy Lines Represent Consecutive Positions of the Car Body

dictate, so that no major change in parts such as location of the engine could be made even though riding-quality would be greatly improved by such a change.

Analysis of Angular Movements in Car Body

In conducting road tests for the riding-quality of an automobile, the resulting motions imparted to the body will be the result of many forces and reactions too involved to be easily analyzed. It is apparent that, if a road test is to be of much value, a relatively long run must be made and some system of integration adopted which will give either total or average results. Integration apparatus can be added to the instrument which will give the total angular velocity, or acceleration, for the entire run.

With the instrument as constructed at present, it was decided to study the angular motions of the car body when passing over a standard bump at different speeds. The size of the wooden bump over which the car was driven in the tests was 5⅝ in. wide by 2⅝ in. high, with the upper corners chamfered 1 in. at a 45-deg. angle. This size was selected as it was found to be too large to be entirely absorbed by the tires and small enough so that the resulting angular velocity of the car does not exceed the calibration of the instrument. The exact size resulted from the use of a standard 2 x 6-in. and a 1 x 6-in. block of hard pine nailed together to make up the bump, which has an advantage in being obtainable anywhere.

With this standard bump fastened to an asphalt expansion joint in a smooth straight portion of concrete paving, and with the Gyro-Accelerometer placed in the car to be tested as shown in Fig. 11, the car was driven over the bump at different speeds. From the resulting record the angular movements about the longitudinal axis can be analyzed. Referring again to Fig. 4, which is typical of records thus obtained, it is apparent that, when the car hits the bump, part of the thrust is absorbed by deformation of the tires, the amount depending upon the velocity and characteristics of the car. The bump being well below the center of gravity of the car, a moment is set up which causes the body to nose down at low and medium speeds before it feels the effect of the upward thrust due to the front wheels passing over the bump. This is shown on Fig. 4 by the small positive loop of the curve when the car hits the bump. The upward thrust at the front causes an angular velocity of the car body in negative or counter-clockwise rotation as viewed from the right side, this velocity being recorded by the first loop of the curve below the zero line. At this time the front of the car is rising with angular velocity as measured by the distance of the curve below zero, and when the curve again passes through zero the front of the car has reached the top of its travel and starts downward. Just before this time, the slope of the curve becomes much steeper, indicating the rapid rate of change of angular velocity or high value of angular acceleration caused by the rear wheels passing over the bump. The time at which this reaction from the rear combines with the motion of the car depends on the speed of the car and the length of the wheelbase. If it combines just before the front end reaches the top of its upward travel, as is the case in Fig. 4, the resulting motion may be described as in the nature of a kick which is very unpleasant. At other speeds the rear-end reaction combines so as to be more or less neutralized by the body motion.

In order to improve the riding-quality, the springs and shock-absorbers should be designed to absorb the maximum energy at the time the period of maximum angular acceleration is produced. By the use of records from the Gyro-Accelerometer taken on a car when driven over the bump at different speeds, it is possible to determine the characteristics required of an absorber to give the car the most desirable riding-quality. In the case of Fig. 4 the maximum energy absorbtion should occur just before maximum travel of the front-end device.

Gyro-Accelerometer Gives Numerical Value of Riding Quality

If a passenger in a car is caused to change the velocity of his motion by the force which the car exerts on him, the experience will be pleasant or otherwise according to the magnitude of the force. The greater the force the more rapid the velocity will change and therefore the larger will be the value of the resulting acceleration. This holds true in angular as well as linear motion and is expressed in mechanics as Force equals the product of mass and acceleration. Because the Gyro-Accelerometer gives an accurate measure of angular acceleration, we have a measure of the force which is proportional to the riding-quality.

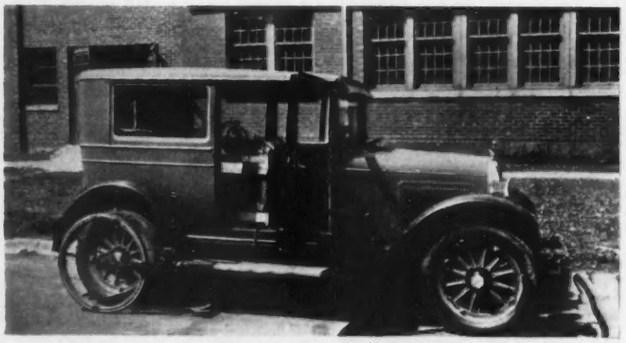


FIG. 11—CAR CARRYING GYRO-ACCELEROMETER FOR TESTING RIDING-QUALITY ON THE ROAD

A Bicycle-Wheel Velocity-Recorder Is Shown Clamped to the Running-Board

Tests have been made at different speeds on cars using the standard-bump method, and the resulting maximum angular accelerations have been found from the records of the Gyro-Accelerometer. Curves drawn with these values plotted against the different speeds give an index of the riding-quality of a car which agrees closely with similar charts prepared from the personal opinion of drivers of these cars. This gives a method of evaluating cars in terms of riding-quality so they can be compared with other cars. Each class of car can thus be assigned a standard riding-quality with which the results of individual cars can be compared. Results of these tests and their comparison with personal-opinion charts will be presented in a future paper.

Because the amount of energy to be absorbed depends on the distance of the radius of gyration from the oscillating center, the determination of this center at any instant is important to the designing engineer, and the instrument furnishes a useful purpose in determining this location.

Production Engineering

Grinding-Wheel Abrasives[1]

Variables in Manufacture and Requirements Analyzed as a Basis for Standardization

MANY are familiar with the standard wheel-shapes and sizes sponsored by the Division of Simplified Practice of the United States Chamber of Commerce, and with the cooperative work done by various wheel-manufacturers, users and machine builders in establishing a guide-book to standardization. Splendid results have been accomplished by directing attention to the multiplicity of dimensional differences existing, and Bulletin No. 45, of the Department of Commerce—Elimination of Waste, Simplified Practice—if followed by all who are interested in the manufacture and application of abrasives, will lead to a lowering of those factors of cost that are affected by the application of the code.

This standardization work on shapes and dimensions has directed attention to standardization of simplified bonds and grade symbols, with the aim of simplifying markings and eventually adopting standard specifications for abrasive wheels that will enable the buyer to purchase from various sources wheels that will give an adequate performance. This will bring to pass in the grinding-wheel industry a situation analogous to that now existing in the steel industry because of S.A.E. steel specifications.

The purpose of this paper is to contribute an analysis of the problem involved and attempt to clarify some of the points which are causing trouble in the application of abrasive products, not to offer a solution of the problem.

A Self-Sharpening Tool

Grinding-wheels are often compared to milling-cutters in their action, or thought of as multiples of cutting-tools of other forms, in trying to arrive at an explanation of certain phenomena which occur. This analogy may be true as to the cutting action of a single abrasive crystal, but it falls far short of being truly descriptive of the actual conditions attending satisfactory grinding-wheel operations. The grinding action of the modern grinding-wheel is often explained or illustrated also in terms of an abrading action similar to that obtained with sandstone. This does not furnish a correct picture, nor do any of the facts brought out by observation of grinding-wheel action fit in with this analogy.

Chips are evidence that the modern grinding-wheel cuts, like any modern cutting-tool; but it differs from the cutting-tool in that it must be self-sharpening on all grinding operations where the demand is for the removal of a large amount of stock rather than for a high degree of accuracy. In grinding operations where accuracy is the predominent factor, the sharpening is left largely to the diamond or other dressing tool, but in such cases another condition differentiates the satisfactory grinding-wheel from the cutting-tool.

Grinding-Wheel Stresses

A grinding-wheel that is giving satisfactory grinding action must be operating under stresses that are close to the ultimate limit of its strength, or that combination of physical characteristics which are built into the wheel to resist working stresses. Any reduction in working stresses will cause the wheel to act "harder"; any increase in working stresses will cause the wheel to act "softer." The grinding-wheel that will give the best grinding action on production work cannot be subjected to variation in working stresses without sacrificing either cutting action or abrasive material.

The stresses developed in grinding during a common cylindrical-grinding operation, for example, are many and varied:

(1) The relation of wheel speed to work speed will determine the shearing force and, in a measure, the compressive force acting on the wheel face.

(2) The rate of traverse accounts for another shearing force acting on the wheel face and is also a factor in the compressive force exerted on the whole or a portion of the wheel face.

(3) The arc of contact between work and wheel face and the in-feed affect the compressive forces on the wheel face, the in-feed being the greater factor.

(4) In service, the abrasive wheel is constantly diminishing in diameter; consequently, the relation of wheel speed to work speed is constantly changing.

(5) The reduction in diameter of the abrasive wheel also constantly decreases the arc of contact between wheel and work.

If this summary of grinding-wheel characteristics is correct, the modern grinding-wheel is differentiated from other production cutting-tools both in inherent characteristics and by the conditions under which it operates.

Each abrasive wheel is composed of an abrasive material and a bond material and is fabricated by some process. These three factors—abrasive, bond, and process—create a further variable—wheel structure.

Variables in Wheel Manufacture

The two distinct abrasive materials commonly used in abrasive wheels are fused aluminum oxide (Al_2O_3) and carbide of silicon (SiC). These are made under different trade names by various manufacturers.

Each grit or grain of aluminous abrasive is composed of a number of individual crystals held together by a matrix of impurities. The matrix can be varied to produce a binder of greater or less strength, to regulate the toughness of each individual grit or grain. In the production of abrasive materials of extremely high purity, additions to the furnace mix and proper adjustment of such conditions as fusing temperatures and cooling rates will result in varying lines of fracture.

Other factors which have a definite result in the action of the fabricated wheel are grit shape and uniformity of grit size, which are subject to control in the crushing and grading. The shape has a definite effect on the action of the abrasive, and uniformity of size and shape must be secured to produce uniform wheels.

Five distinct types of bonding material are used: clays (vitrified); rubber (vulcanite); shellac (elastic); synthetic resin, such as Redmanol or Bakelite; and a silicate, such as sodium silicate. Each of these bonding materials imparts definite characteristics to the abrasive wheel in which it is used and each has a rather definite field of application, although their fields overlap to some extent.

Further, variation in processes can be made in fabricating wheels with any one of these bonds. Consider for a moment the possibilities in vitrified or clay bonds, plus process variations. A number of clays or clay mixtures can be used by the ceramic engineer to produce variations in bonding characteristics; and two distinct and well devel-

[1] Paper read by Boyd H. Work, of the sales engineering department of the carburundum Co., Niagara Falls, N. Y., at the Annual Meeting.

oped processes are in common use, the puddled process and the pressed process.

Possible Range in Wheels

With the same bonding materials, process changes introduce changes in wheel structure that reflect themselves in wheel action. Wheel structures can also be varied by the use of several different grit sizes instead of only one. From this it can be seen that the wheel manufacturers have a number of different approaches to the solution of any grinding problem. The various fields of production grinding require two distinct abrasive materials, having variations in structure which result in four abrasives, and five distinct types of bond with two and sometimes three processes applied to each type. There are wheels of at least 15 grits or grain sizes, in a range of approximately 10 grades, in common use on production cylindrical-grinding jobs.

A question often asked is, Why is there a difference in action between wheels of the same grading or same relative grading made by different manufacturers? The production of the modern grinding-wheel is not a question of some technical detail in manufacture so much as it is in the result of a complete system including an infinite number of details. Since each plant has grown up largely within itself, it is only natural to expect that the resulting products, though they may accomplish identical results, are far from identical. Although wheels from two manufacturers may be equally good and be made of the same grit size and with the same type of bond, there undoubtedly are differences in grain, bonding, and structure. These differences may not be apparent on one operation but may affect wheel action very noticeably on another operation.

To carry this work of simplification further, the wheel manufacturer's individual problem is to develop, from an immense field of possibilities, a wheel of maximum flexibility or range which will cover the widest field of application. The wheel manufacturers' group problem presents only one workable plan for simplification—a common scale of grits and grades. To establish this, cooperative work must be carried on so that the products of various makes can be brought into true relation with respect to the identifying symbols and their relative wheel actions. This problem is complicated by the fact that the physical tests that can be made on the wheel up to the present bear no direct or constant relation to the action of the wheel in use, being comparable in this respect to hardness tests of steel.

Variables in Use

The following factors affect wheel selection and performance in the user's plant:

(1) Type of machine
  (*a*) Size (in relation to work)
  (*b*) Type of control (automatic or hand feed).
  (*c*) Power and drive
  (*d*) Condition of spindle bearings
(2) Work speed
  (*a*) Rotation
  (*b*) Traverse
  (*c*) Relation to wheel speed
(3) Wheel speed
  (*a*) Rotation
  (*b*) Traverse
  (*c*) Relation to work speed
(4) Feed
  (*a*) Total stock to be removed
  (*b*) Rate
(5) Grinding compound or coolant
(6) Method, set-up
(7) Dressing and truing

An illustration will indicate the effect of these variables on the problem of standardization. Similar, or even identical, parts are being ground on a production basis in different shops with wheels varying in diameter from 16 to 30 in., with stock removal varying from 0.025 to 0.060 in. In one case the wheel and work speeds remain constant, and in another the work speed and feed are carefully balanced to maintain grinding efficiency throughout the entire life of the wheel. Set-up and method differ, and the dressing tools are of different types. This comparison is not an exaggeration; it is not unusual to find, even in the same plant, identical machines and set-ups running at different work and wheel speeds. However, splendid work has been done in various plants and organizations to furnish standard operating conditions for abrasive products, and this work has paid dividends. There is much more to be done.

The consumer's or user's problem, then, is to standardize equipment and operating conditions so that one type, or grit and grade, of abrasive product can be used efficiently on a greater variety of operations.

The third phase of this problem involves the machine builder. Since grinding-wheel action and the results the user can obtain are dependent upon certain points of machine design, the machine builder must provide ranges of work speeds and wheel speeds so that the operator can make adjustments according to conditions. Efficient and economical use of abrasives can be attained only through the correlated efforts of the abrasive manufacturer, the machine builder and the ultimate consumer.

The very fact that wheels of such a wide variety of grits and grades are being manufactured in various types and used on production jobs indicates that many special conditions are encountered in the broad field of industry. One important variable that has not been mentioned is the material to be ground. Little can be done to simplify the abrasive requirements in this respect, as the physical characteristics of various ferrous or non-ferrous metals require special abrasive treatment. There is a marked increase in the demand for special types of abrasive products as metallurgical science progresses in the production of special alloy-steels and metals for cutting-tools and as grinding operations are extended among non-metallic materials.

Further complications are being brought about by the fact that new grinding-machines, involving new principles and methods of abrasive application, are being placed on the market constantly. Examples are the relatively recent developments of semi-automatic and full-automatic internal grinders, automatic features on cylindrical grinders, and the introduction of hydraulic feeds and control on various types of grinding equipment.

In the light of what has been accomplished in this work during the last year toward reconciliation of diversified tendencies by standardization, may we not assume that a friendly understanding of our mutual problems, coupled with cooperative effort, offers a solution of this great problem?

Metal-Cutting with Diamond Tools

Report of Subcommittee of the Production Committee, Based on Questionnaire Sent to Manufacturers

FOLLOWING the preparation of an article on this subject which appeared in the Production Engineering Department of the S.A.E. JOURNAL for October, 1928, a questionnaire was sent to leading manufacturers, particularly in the automotive field, for definite information on their practice. A preliminary tabulation of the replies received was given at the Production Meeting of the Society in Detroit last November by the Subcommittee on Processes and Equipment. G. W. Blackington, who was the chairman of this group, has now completed work on the subject.

Questions were addressed to 39 motor-car manufacturers, 13 motor-car and aeronautic engine manufacturers, and 13 other manufacturers. Including among the last 13 were makers of machine-tools who were reported to be interested in the subject of heavy machinery and of electrical machinery. Nearly all of the automotive manufacturers replied, either sending complete

TABLE 1—MACHINING CONNECTING-RODS WITH DIAMOND TOOLS

	Large End, Babbitt					Small End, Bronze					Data Applying to Both Ends				
Factory	Diameter, In.	Cutting Speed R.P.M.	Cutting Speed F.P.M.	Feed per Revolution, In.	Single Depth of Cut, In.	Diameter, In.	Cutting Speed R.P.M.	Cutting Speed F.P.M.	Feed per Revolution, In.	Single Depth of Cut, In.	Parts per Hr.	In Use, Years	Lubricant	Shape of Tool	Make of Machine
Cadillac	2.376	1750	1088	0.0015	0.010	0.8746	3500	802	0.00075	0.005	45	3½	S	R	Own
Continental	.....	....	....	.....	.....	0.735	3600	....	0.0015	0.0015	120	1	G	R	Own, 2-Sp'dle
Ford	.....	....	....	.....	.....	0.993	3100	....	0.036	0.0075	360	⅛	S	..	Coulter
Graham	2.125	2200	....	0.0016	0.007	.....	....	....	.....	.....	136	1	O	B	Coulter
Hupp	2.125	1850	1029	0.0023	0.007	0.985	2900	902	0.0013	0.007	100	1	M	R	Coulter
LaFrance	2.2520	1725	1016	0.0125	0.011	.....	....	....	.....	.....	80	New	None	R	Own
LaFrance	.....	....	....	.....	.....	1.250	1725	565	0.0125	0.007	90	New	None	R	Own
Lycoming	2.125	2000	....	0.0028	0.0055	.....	....	....	.....	.....	90	1	S	..	Coulter
Mack	2.375	1300	810	0.0051	0.017	.....	....	....	.....	.....	22	6	C	R	Heald
Nash	2.250	1600	....	0.0025	0.010	0.9275	2850	....	0.0025	0.003	84	1½	O	R	Schraner
Packard	2.189	1527	875	0.0018	0.010	0.8755	3054	700	0.0009	0.003	70	5	S	R	Coulter
Stutz	2.377	500	308	0.0025	0.005	0.8748	500	115	0.0025	0.005	17½	2	O	R	Sidney Lathe
Wilson	2.000	1780	932	0.0014	0.0065	0.7968	3300	688	0.0076	0.0035	58.8	2	C	R	Own
Wright	1.182	3200	....	0.001	0.0035	0.875	3200	....	0.001	0.0035	50	⅛	S	..	Coulter
Coulter	2.000	1000	1000	0.004	0.005	1.000	4000	1000	0.002	0.005	120	2	C	S	Coulter

Symbols—Lubricants: G, grinding compound; M, mineral lard-oil and soda-water; O, oil; S, soluble oil.
Shape of Tool: B, blunt nose; R, round nose; S, square nose.

data or stating that they are not using diamond tools or have not used them long enough to give a report of value. One machine-tool manufacturer gave recommendations based on experience with a boring machine designed specially for diamond-tool work. Most of the information secured is given in Table 1, which shows the practice followed in boring the large and small ends of connecting-rods, and in Table 2, which gives information on boring operations in crankcases and other parts. No turning operations were reported with definite data.

Names given in the tables stand for full company names, as follows: Graham, Graham-Paige Motors Corp.; LaFrance, American LaFrance & Foamite Corp., Inc.; Mack, International Motor Co., Plainfield plant; Nash, Nash Motors Co., Kenosha plant; Wilson, Wilson Foundry & Machine Co.; Wright, Wright Aeronautical Corp.; Coulter, Automatic Machine Co.

It is hardly possible to draw definite general conclusions from the data secured, but they will doubtless serve as a guide to production men contemplating similar applications, and perhaps to some of the present users as an indication of the possibilities of increasing the cutting speeds now being used by them.

Life of Diamond Tools

Not much definite information was acquired on the cost and life of diamond tools, but the Nash Motors Co. reported that the average life of its tools was two months in cutting babbitt, 1½ months in bronze, and 2 years in machining the bronze bushings in a cluster of gears used in the transmission. Two bushings in this cluster are machined simultaneously with two diamond tools. The diamonds are set in ¼-in. and ⅜-in.-diameter tips held in boring-bars running in bearings. The Stutz Motor Car Co. of America reported an average life of the diamond tools it is using sufficient to finish 2000 connecting-rods per diamond. It is doing the work in a Sidney lathe fitted with fixtures of its own design. The International Motor Co. reports that its cutting is done at low speed because of the equipment, and that the diamond expense is so low that it can hardly be calculated.

Nearly all of the manufacturers reporting on the shape of the tools describe them as round-nose type, Nash Motors Co. giving the radius of the point as 5 in. The Graham-Paige Motors Corp. reported using a shape similar to a blunt-nose lathe turning-tool, having a back rake and front cutting clearance. Square-nose tools are recommended by the Automatic Machine Co., builders of the Coulter automatic diamond-tool boring-machines. Its recommendations for connecting-rod boring are given at the bottom of Table 1, and for boring piston-pin holes in pistons in the second line of Table 2. Users of round-nosed tools are indicated by *R* in both tables.

Soluble oil seems to be most generally used as a cutting compound or lubricant. Some variations of the name appeared in the answers to the questionnaire, and they are reported in the tables as given in the replies.

The possibility of holding dimensions within very close tolerances is illustrated by the practice of the Packard Motor Car Co., which holds both bores of the connecting-rod within a tolerance of plus or minus 0.0001 in.

TABLE 2—MACHINING MISCELLANEOUS PARTS WITH DIAMOND TOOLS

Factory	Diameter, In.	Cutting Speed R.P.M.	Cutting Speed F.P.M.	Fuel per Revolution, In.	Depth of Single Cut, In.	Parts per Hr.	In Use, Years	Lubricant	Shape of Tool	Make of Machine
Piston-Pin Hole in Piston										
Mack	1.4375	1340	505	0.002	0.008	28	6	C	R	Heald
Coulter	1.000	4000	1000	.....	.....	100	1	C	S	Coulter
Main Bearings[1]										
Mack	2.932	125	96	0.006	0.0025	4	6	None	R	Rockford
Main-Bearing Bores in Crankcase, Aluminum										
Cadillac	2.812	1680	1236	0.0013	0.0075	14	1½	None	..	Own
Camshaft-Bearing Bores in Crankcase, Aluminum										
Cadillac	2.625	1750	1203	0.00125	0.005	14	1½	None	..	Own
Camshaft Rear-Bearing, Cast Iron										
Packard	1.375	1600	576	0.0013	0.005	30	3	K	R	Reed Lathe
Transmission Cluster-Gear Bushing, Bronze										
Nash	0.990	1700	....	0.0025	0.0025	27	2½	None	R	Old Lathe
Reverse Gear										
Nash	0.990	1700	....	0.0025	0.0025	35	New	None	R	Old Lathe
Shaft Bearing in Shock-Absorber Housing, Bronze										
Packard	1.000	3300	864	0.0005	0.008	80	⅔	S	R	Coulter

Symbols—Lubricants: C, compound; K, kerosene; S, soluble oil. Shape of Tool: R, round nose; S, square nose.
[1] These bearings are of progressive sizes, the largest being 2.969 in. in diameter.

Standardization Activities

Engine Division Action

Division Approves Two Recommended Practices and Asks Cancelling of Several Obsolete Specifications

THE ENGINE Division, at its meeting on April 29 in Detroit, disposed of a number of subjects that have been under consideration for the last few months, dropped from consideration several projected topics, cancelled four specifications which have become obsolete, and approved two new recommended practices and an addition to one existing standard.

Engine Rear-Support Arms

Some confusion has been found to exist because the No. 2 engine rear-support arm is often assumed to be intended for use on a No. 2 bell-housing, whereas in general practice the No. 3 arm usually is used on this housing. Discussion at the meeting brought out the sentiment that, while no direct reference is made to such usage in the specifications for either the flywheel housing or the engine rear-support arm, some action, if possible, that will prevent this inference is desirable. The Division further thought that, because the No. 2 arm is almost never used in present engine design, the dimensions for the No. 2 rear-support arm should be eliminated from the standard in their entirety.

Consequently, the Engine Division recommends that the Standards Committee approve cancellation from the S.A.E. Standard on Engine Rear-Support Arms, p. 46 of the 1929 edition of the S.A.E. HANDBOOK, of the size No. 2 arm and the dimensions therefore.

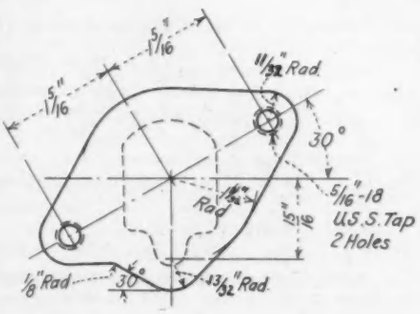
Fuel-Pumps

The use of fuel-pumps on automobile engines has increased so rapidly in the last 12 months as to attract a number of manufacturers to design and manufacture such equipment. At the same time, a number of mounting-flange designs have made their appearance, causing considerable confusion, particularly when mounting various pumps on engines for test. Therefore, the Engine Division was asked to approve a standard mounting-flange and to endeavor to secure the general usage of such a mounting-flange by all fuel-pump manufacturers.

In collecting information on this subject it was found that two types of pump are in use at present. These are the reciprocating type, which is used most extensively, and the rotary type. It was not thought advisable to adopt any flange as an S.A.E. Standard, because of the relatively short time fuel-pumps have been in use and the possibility of further development and design which may affect the mounting; but it is deemed desirable to approve a mounting-flange for the reciprocating type and also one for the rotary type, each as a separate S.A.E. Recommended Practice. Consequently, the Division recommends that the Standards Committee approve the accompanying mounting flanges as S.A.E. Recommended Practices:

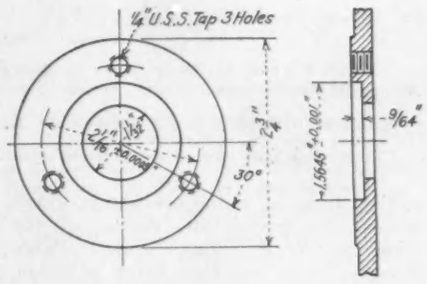
FUEL-PUMP MOUNTING-FLANGE, RECIPROCATING TYPE

(Proposed S.A.E. Recommended Practice)



FUEL-PUMP MOUNTING, ROTARY TYPE

(Proposed S.A.E. Recommended Practice)



Drain Cocks

At the suggestion of one of the radiator manufacturers, consideration was given to the addition of a paragraph to the S.A.E. Specifications on Shell-Type Radiators, to provide a minimum drain-cock size by specifying the size of the tapped hole. By providing a sufficiently large hole and a correspondingly large drain-cock, the Division felt that better drainage and consequently better cleaning and operation of radiators will be obtained. Therefore the Division recommends that the Standards Committee approve the addition to the S.A.E. Standard on Shell-Type Radiators, p. 61 of the 1929 edition of the S.A.E. HANDBOOK, of the following:

Drains.—The minimum size of the tapped hole for the radiator drain-cock or plug shall be ⅜ in. American Standard pipe thread.

Engine-Testing Forms

Revision of the present S.A.E. Engine-Testing Forms to incorporate various suggestions received with reference to allowance for the use of mufflers, generators and so forth on engines under test was considered, but those present felt that insufficient data were at hand to determine whether any revisions are necessary. The consensus of opinion was that further study should be given this matter, particularly in connection with the work being done by the General Motors Corp. on engine testing; therefore, the entire subject was referred to the Subdivision on Engine-Testing Forms, with the request that it ascertain whether the present forms are satisfactory or some revision should be made, and, if revision is desirable, that it recommend the changes.

Engine-Number Location

Similarly, with regard to the advisability of a specification for engine-number location, the opinion was expressed that the best location of the number is entirely dependent upon the engine design and no influence can be exerted through the medium of a standard. Therefore the Standards Committee is asked to approve cancellation of the S.A.E. Standard on Engine-Number Location, p. 56 of the 1929 edition of the S.A.E. HANDBOOK.

Engine-Type Tire-Pump Mountings

As the engine-type tire-pump has virtually disappeared from use, the Standards Committee is asked to approve cancellation of the S.A.E. Standard on Engine-Type Tire-Pump Mountings, p. 56 of the 1929 edition of the S.A.E. HANDBOOK.

A number of other subjects sug-

gested for standardization were taken up by the Engine Division at the April 29 meeting, but no action was taken because the subjects seemed unsuitable for standardization.

Exhaust Pipes and Mufflers

The question of revising the present S.A.E. Specifications on Mufflers and Exhaust Pipes, which has been in the hands of a Subdivision for some months, was discussed, with the result that, as the design of the muffler is in the majority of cases entirely dependent on the characteristics of the engine with which the muffler is to be used, a standard such as that already in existence is believed to be of no value whatever.

The same condition obtains with regard to exhaust-pipe sizes. Consequently, the Standards Committee will be asked to approve cancellation of the S.A.E. Recommended Practices on Mufflers and Exhaust Pipes, p. 55 of the 1929 edition of the S.A.E. HANDBOOK.

Action by Passenger-Car Division

Several Subjects Dropped — Collecting Data on Body Nomenclature and Non-Shatterable Glass

THE Passenger-Car Division met in Detroit on April 30 to determine the disposition of several subjects which have been under consideration for some time.

Steering-Wheel Hubs

The question of revising the present S.A.E. Specifications on Steering-Wheel Hubs was discussed at length, as it has been determined that these specifications as now constituted are but little used. The practice of steering-wheel manufacturers varies considerably in the one basic dimension which governs the interchangeability of steering-wheels on shafts, namely, the taper, and it is felt that unless some agreement can be reached by the various manufacturers on one standard taper a specification on steering-wheel hubs will have no value. Therefore, the division recommends to the Standards Committee that the specifications on Steering-Wheel Hubs, pp. 222 and 223 of the 1929 edition of the S.A.E. HANDBOOK, be cancelled. This action is taken with the understanding that an attempt will be made to bring the steering-wheel manufacturers together on the matter of the hub taper and if this is successful a complete hub specification will be developed.

Spark and Throttle Levers

It was suggested that the Division consider the feasibility of standardizing the location and direction of operation of spark and throttle levers, but because appearance, design and other factors govern these features of spark and throttle levers to a great extent, it was believed impractical for the Society to attempt to standardize them. Therefore no further consideration will be given to this subject.

Automobile Visors

In a letter from the California State Automobile Association to the National Automobile Chamber of Commerce, which had been referred to the Passenger-Car Division, a suggestion was made that some step be taken to standardize the height of automobile visors to afford ready visibility of high-hung traffic signals. Standardization of this kind involves the height of driver, height of seat and so many automobile body dimensions that it was felt no standard could ever be set up that would be of value or affect the situation. It is the opinion that the subject is one for consideration of the National Safety Council or similar bodies, which could promulgate requirements to provide adequate safety in this respect.

Black Baking Enamel

In 1924 a Subdivision of the Passenger-Car Division was organized to investigate the possibility of writing specifications for paints, varnishes and enamels. In an effort to determine whether this was feasible, the Subdivision selected one material—black baking enamel—on which to conduct its first research. Laboratory experiments and exposure tests conducted since that time have resulted in an opinion that it is impractical to attempt to write any material specifications for this type of material.

The report on this subject presented by Mr. Graves, of the Packard Motor Car Co., recommended to the American Society for Testing Materials that some test specifications for the hardness of enamels be developed.

The Subdivision was discharged, with the thanks of the Division, and no further consideration will be given to this subject.

Automobile Trunk-Racks

A letter recently received from one of the trunk-rack manufacturers was circulated among other such manufacturers to ascertain their views on the possibility of standardizing automobile trunk-racks. The replies were submitted to the Passenger-Car Division and, while one or two manufacturers suggested that such standardization would be desirable, no concrete suggestions were offered in any of the letters. The Division therefore felt that the subject is unsuitable for standardization, as interchangeability of trunk-racks would be impossible owing to body design and to the many accessories attached to the rear of cars. It was voted to give no further consideration of this subject.

Body-Type Nomenclature

The Standards Department has, for several weeks, been compiling information on the various names given to different types of body by passenger-car and body manufacturers. These data have not been completely gathered, but when all replies to the inquiry have been received, a summary of the answers will be made and submitted to a special Subdivision for the outlining of a proposed revision of the present specifications on body-type nomenclature.

It is possible that a basic name may be determined for each type of body and a list of alternate names provided, so that correct identification can be made. While no report on this subject will be forthcoming for the Standards Committee meeting in June, it is anticipated that the final report will be submitted to the Division early in the autumn.

Non-Shatterable Glass

A survey of the manufacturers of non-shatterable glass is being conducted at present by the Standards Department to determine the different specifications now in use for this material. Each manufacturer now has his own tests and standards, but there has been no agreement among them. It is felt that if the Society could evolve some standard of tests and manufacture it would be of considerable value. Following a suggestion from H. C. Mougey, of the General Motors Corp. Research Laboratories, an attempt will be made to obtain from the various companies their specifications for the following properties:

(1) Quality, i. e. freedom from dirt and imperfections in the pyralin or glass, or both

(2) Permanence of adhesion, as determined by laboratory tests such as heating in an oven, boiling in water or heating in oil

(3) Resistance to shattering, as determined by a drop-ball test on a certain size test-piece under certain definite conditions

(4) Resistance to shattering at low temperatures, as determined by a drop-ball test at temperatures below 30 deg. fahr.

(5) Resistance to discoloration, as determined by either ultra-violet-light tests or exposure to sunlight under severe conditions such as those existing in Florida.

When this information is obtained the subject will be submitted to a Subdivision of the Passenger-Car Division in an endeavor to obtain a definite recommendation.

Non-Metallic Flexible Conduit

Revised Specifications To Be Submitted to Standards Committee by Electrical-Equipment Division

BECAUSE of some criticism of the present S.A.E. Specifications on Non-Metallic Flexible Conduit, on p. 172 of the 1929 edition of the HANDBOOK, a proposed revision was sent to members of the Electrical Equipment Division on Jan. 12 for comment. The replies and suggestions were referred to L. O. Parker for coordination into a final draft, and copies of this revision were mailed on April 4 to Division members for their final approval by letter-ballot.

As there is an insufficient number of subjects to warrant holding an Electrical Equipment Division meeting prior to the Standards Committee meeting in June, this report will be presented to the Standards Committee on the basis of the results of the letter-ballot with no further Division action. The complete proposed revision is as follows:

NON-METALLIC FLEXIBLE CONDUIT

(*S.A.E. Recommended Practice*)

General Information.—Non-metallic flexible conduit is recommended for use as insulated covering over insulated cables as additional mechanical protection; also as protection to the cable from water, oil and grease. This non-metallic conduit is also recommended for use as a covering for copper or other metal tubing to prevent crystallization and eliminate unnecessary rattles.

Construction.—This conduit shall be of single-wall construction of closely woven cotton-warp strands interlocking around twisted Kraft-paper fillers that will not unravel and must have sufficient mechanical strength before impregnation. The finished conduit of the size specified shall slip freely over a 12-in. long polished mandrel of the dimension given as the minimum inside diameter. This dimension is the size under which the conduit will be referred to and shall not vary from the size given more than minus 0.000 to plus 0.020-in. Standard sizes are listed in the following table, with respective paper and cotton requirements. Values given in the table are minimum figures unless otherwise designated.

Size	Maximum Outside Diameter, In.	Approximate Weight per 1000 Ft., Lb.	Paper Filler Diameter, In.	Picks per Inch	Yarn Size	Ends per Needle	Total Yarn Ends
3/16	0.300	14.0	0.035	13	14-2	2	56
1/4	0.368	19.5	0.035	13	14-2	2	64
5/16	0.448	21.5	0.035	13	14-2	2 and 3	73
3/8	0.513	26.0	0.050	11½	14-2	2	96
7/16	0.577	29.5	0.050	11½	14-2	2	128
1/2	0.640	32.0	0.050	11½	14-2	2	128
9/16	0.732	40.0	0.065	10½	14-2	2 and 3	134
5/8	0.795	46.0	0.065	10½	14-2	2 and 3	148
11/16	0.862	55.0	0.065	10½	14-2	2 and 3	152
3/4	0.960	62.0	0.080	9½	14-2	3	192
13/16	1.023	75.0	0.080	9½	14-2	3 and 4	212
7/8	1.085	87.5	0.080	9½	14-2	3 and 4	230
15/16	1.161	90.0	0.087	9	14-2	3 and 4	240
1	1.224	92.5	0.087	9	14-2	4	256

Saturation.—The conduit must be thoroughly impregnated inside and out with a water, oil and acid-resisting compound and must be free from heavy or gummy deposits of the impregnating compound. This impregnation is introduced to prevent moisture absorption, to bind the weave to the required wall strength and to prevent fraying of the cotton ends. The polished mandrels used for checking the inside diameters shall show no sticking or discoloration at any temperature up to 150 deg. fahr. The compound must not drip from the conduit when submitted to a temperature of 220 deg. fahr. for 15 min. The ends of the conduit must not fray or the weave separate readily when the end is cut at a 90-deg. angle.

Finish.—The conduit must be finished with at least two coats of black pyroxylin lacquer producing a good luster and a good bond to the fabric. The lacquer must be thoroughly dried before wrapping or boxing for shipment. The use of heavy finishes or saturators to give artificial appearance is not permitted. The pyroxylin must be sufficiently plasticized that it will not crack on a piece of conduit kept three months at room temperature when the conduit is bent back sharply on itself.

Conduit with finish of a higher luster than can be obtained with the two coats of lacquer as specified above shall be considered special and should be covered by other specifications when required.

Tests.—(*a*) A 6-in. piece of conduit, totally immersed in water at 70 deg. fahr, for 24 hr., and then blown out with a mild air-current immediately after removing from the water, shall not have an increase in weight of more than 35 per cent.

(*b*) A 6-in. piece of conduit, totally immersed in an equal mixture of cylinder oil, kerosene and gasoline at 70 deg. fahr. for 24 hr., shall not swell appreciably and shall not soften more than 20 per cent, nor shall the lacquer finish separate or freely peel from the fabric after this test.

(*c*) The wall must not collapse when the conduit is bent to a radius of five times the inside diameter at 70 deg. fahr. The conduit shall be capable of being flattened with a wooden mallet for a length of 6 in. in the center of a longer length and of being restored to roundness by working with the fingers so that a wire of maximum size for which it is normally suitable can be readily introduced. The compound must not crack open in this test.

(*d*) All conduit up to and including ⅜-in. inside diameter shall be capable of standing a tension of 100 lb. for 5 min. without breaking or opening at any point. Larger sizes must stand 150 lb. The test piece to be 6 in. long between supports.

Fireproofing. — Flame-resisting qualities must be incorporated in the saturator or finish or both, in order to pass the following test:

> The conduit shall not convey fire nor support combustion for more than 1 min. after five 15-sec. applications of a standard test-flame with intervals of 15 sec. between applications. A standard test-flame is the blue flame, about 5 in. high, produced by a ½-in. Bunsen burner fed with ordinary illuminating gas at normal pressure. The conduit must be held vertically with either the lower or the upper end thoroughly sealed to prevent the passage of air, and the flame must be applied horizontally.

This conduit may be purchased cut to length or in coils, as specified, and must be properly boxed to prevent loss or injury during shipment.

Tires and Rims

New and Revised Specifications on Solid, Balloon, Cushion and High-Pressure Tires and Rims

THE MEETING of the Tire and Rim Division on May 1 was given over in large part to consideration of the specifications for tires and rims for commercial vehicles.

Present S.A.E. Specifications on Solid Tires were revised and a new specification on cushion tires approved. The Division revised the present S.A.E. Specification on Solid-Tire Base-Bands and approved a new recommended practice on dual-mounting spacing of tires.

The present S.A.E. Specification on High-Pressure Pneumatic Tires and Rims was cancelled and in its place the Division approved for submission to the Standards Committee proposed new standards on balloon and high-pressures tires and rims for commercial vehicles, and recommended the approval of three new recommended practices in the form of load and inflation tables for balloon tires for passenger-cars and balloon tires and high-pressure tires for commercial vehicles.

As the present specifications for pneumatic-tire rim sections are obsolete, the Division has recommended that these be cancelled and a revision, in the form of the specifications recently approved by the Tire and Rim Association for pneumatic-tire rims, be approved.

The Division voted to eliminate the 5.50-20 tire size from the present S.A.E. Specifications on Balloon Tires and Rims for Passenger-Cars, as this size is finding very little use. As has already been reported in these columns, the Division, at its meeting last January, recommended elimination of the 5.25-18 and the 4.75-19 sizes. Discussion on this action at the May 1 meeting, particularly with reference to possible reinstatement of the 5.25-18 size, brought out the fact that the letter-ballot of the Division on the original action was overwhelmingly in favor of dropping this size, and, although some argument was made in favor of reinstatement, the Division decided to recommend to the Standards Committee the cancellation of the 5.25-18.

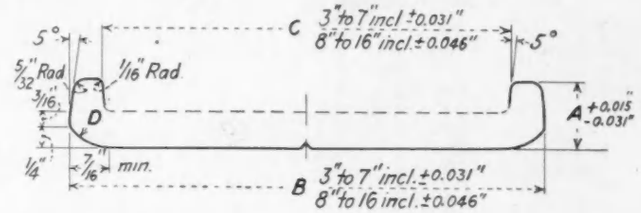
The tire and rim specifications and the various revisions, as they will be presented to the Standards Committee at the Summer Meeting are given in the accompanying tables.

High-Pressure Tires

Cancellation of the passenger-car sizes in that part of the present S.A.E. Standard on Pneumatic-Tire Rims for High-Pressure Tires which appears on p. 336 of the 1929 edition of the HANDBOOK is recommended, and the Standards Committee is asked to approve the proposed S.A.E. Standard on High-Pressure Tires and Rims for Commercial Vehicles as a revision of that part of the present specifications dealing with motor-truck sizes.

Solid-Tire Base-Bands

The Division recommends the revision of the present S.A.E. Specification on Solid-Tire Base-Bands, p. 340 of the 1929 edition of the HANDBOOK, to read in accordance with the accompanying specification.



Solid Tires

The Division requests the Standards Committee's approval of the revision of the present S.A.E. Specifications on Solid Tires, p. 339 of the 1929 edition of the HANDBOOK, as shown in the accompanying table.

SOLID-TIRE BASE-BANDS

(*Proposed S.A.E. Standard*)

Base-Band Size, In.	*A*	*B*	*C*	*D*
3	23/32	3¾	3 1/16	5/8
3½	3/4	4¼	3 9/16	5/8
4	25/32	4 13/16	4 1/16	5/8
5	27/32	5⅞	5 1/16	5/8
6	27/32	6⅞	6 1/16	5/8
7	27/32	7⅞	7 1/16	5/8
8	7/8	8⅞	8	7/8
9	7/8	9⅞	9	7/8
10	7/8	10⅞	10	7/8
12	7/8	12⅞	12	7/8
14	7/8	14⅞	14	7/8
16	7/8	16⅞	16	7/8

Note 1.—Channel base-bands used for all solid, cushion, tractor, trailer and industrial truck tires are included in this standard.

Note. 2.—Design of corrugations in surface of band between flanges is optional.

Note. 3.—The standard width of solid tires is the nominal width in inches as measured inside the channel at the mean of the vertical seat of rubber, the tolerances being plus or minus 1/16 in.

SOLID TIRES

(*Proposed S.A.E. Standard*)

Nominal Tire Size, In.	Fits Wheel Diameter, In.	Maximum Carrying Capacity per Tire, Lb.	Maximum Recommended Speed, M.P.H. (See Note T)
32x3[a]	26	950	22
34x3-T	28	1,000	22
36x3[a]	30	1,000	22
32x3½-T	26	1,350	22
34x3½[a]	28	1,425	22
36x3½[a]	30	1,425	22
32x4-T	26	1,800	22
34x4[a]	28	1,900	22
36x4	30	1,900	22
32x5-T	26	2,700	22
34x5[a]	28	2,850	22
36x5	30	2,850	22
40x5[a]	34	3,000	22
32x6-T	26	3,600	18
34x6[a]	28	3,800	18
36x6	30	3,800	18
40x6[a]	34	4,000	18
28x7-T	22	4,250	18
34x7[a]	28	4,750	18
36x7	30	4,750	18
40x7	34	5,000	18
28x8-T	22	5,100	18
34x8[a]	28	5,700	18
36x8	30	5,700	18
40x8	34	6,000	18
28x10-T	22	6,800	18
36x10	30	7,600	18
40x10[a]	34	8,000	18
28x12-T	22	8,500	18
36x12	30	9,500	18
40x12	34	10,000	18
28x14-T	22	10,200	18
36x14	30	11,400	18
40x14	34	12,000	18
40x16	34	14,000	18

Sizes underlined are recommended for use on new models.

[a] The use of these sizes on new models is not recommended. The tires are still being used to a limited extent by trucks manufacturers on existing models.

T—These tires are for use on trailers only. Trailers and other vehicles without springs are limited to speeds of 6 m.p.h. when loaded and 12 m.p.h. when unloaded.

Note 1.—For dual tires use double the carrying capacity of corresponding singles.

Note 2.—Recommended carrying capacities and speeds are for vehicles equipped with springs.

Truck and Bus Balloon Tires

The Standards Committee is requested to approve the accompanying table on balloon tires and rims for commercial vehicles as an S.A.E. Standard.

PNEUMATIC TIRES AND RIMS FOR COMMERCIAL VEHICLES

(*Proposed S.A.E. Standard*)

Rim Diameter, In.	Tire Sections, In. 5	6	7	8	9	10
20	30x5	32x6	34x7	36x8	38x9	40x10
24	34x5	36x6	38x7	40x8	42x9	40x10
Nominal Rim-Section Width, In.	5	6	7	8	9	10
Maximum Tire Width on Rim, In.	6.05	6.90[a]	8.05	9.20	9.85	11.50

[a] Eight-ply 6-in. tire to be 6.55 in. maximum on 5-in. truck rim.

BALLOON TIRES AND RIMS FOR COMMERCIAL VEHICLES

(*Proposed S.A.E. Standard*)

Rim Diameter, In.	Tire Sections 6.00	7.00	7.50	8.25	9.00	9.75	10.50
20	6.00–20	7.00–20	7.50–20	8.25–20	9.00–20	9.75–20	10.50–20
22				8.25–22	9.00–22	9.75–22	10.50–22
Nominal Rim-Section Width, In.	5	5	6	7	7	8	8
Maximum Tire Width on Rim, In.	6.05	6.95	7.75	8.50	9.25	10.05	10.30

Dual Spacing for Truck and Bus High-Pressure and Balloon Tires

(Proposed S.A.E. Recommended Practice)

Rim Size, In.	Tire Size, In.	Spacing (Center to Center Tires and Rim), In.
5	5	7
5	5 (6)	7¾
6	6	7¾
6	7.00	8¼
6	6 (7)	8 13/16
6	7.00 7.50	8 13/16
7	7	9
7	7.50 8.25	10
7	7 (8)	10
7	8.25 9.00	10½
8	8	10¼
8	8 9	11½
8	9.00 9.75	11½
8	9.75 10.50	12
9-10	9	12
9-10	9 10	12¾
9-10	10.50	12¾

Note.—Tire and rim combinations show in brackets should not be used as original equipment.

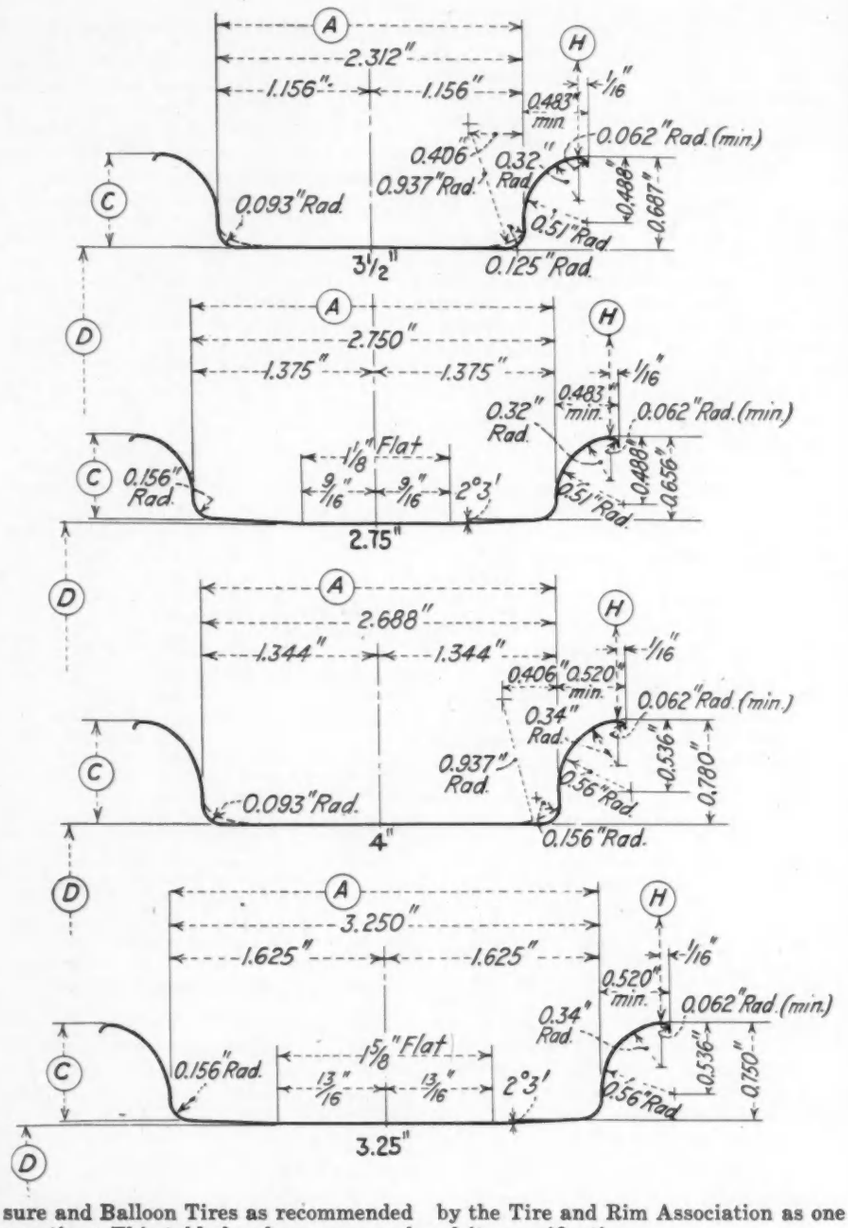
(Approved by the Tire and Rim Association.)

Load and Inflation Tables

Incorporation in the S.A.E. Specifications of some information on load and inflation pressures for balloon tires for passenger-cars and commercial vehicles and for high-pressure tires for commercial vehicles was felt to be advisable and, as the Tire and Rim Association has approved such tables for publication in its handbook on specifications, the S.A.E. Tire and Rim Division decided to recommend that the tables be adopted as new S.A.E. Recommended Practices.

Dual-Tire Spacing

Present S.A.E. Specifications contain no information on the spacing of dual mounted tires. To supply data to meet this deficiency, the Division requests approval of the table on Dual Spacing for Truck and Motorcoach High-Pressure and Balloon Tires as recommended practice. This table has been approved by the Tire and Rim Association as one of its specifications.



Balloon Tires and Rims for Passenger-Cars

(S.A.E. Standard)

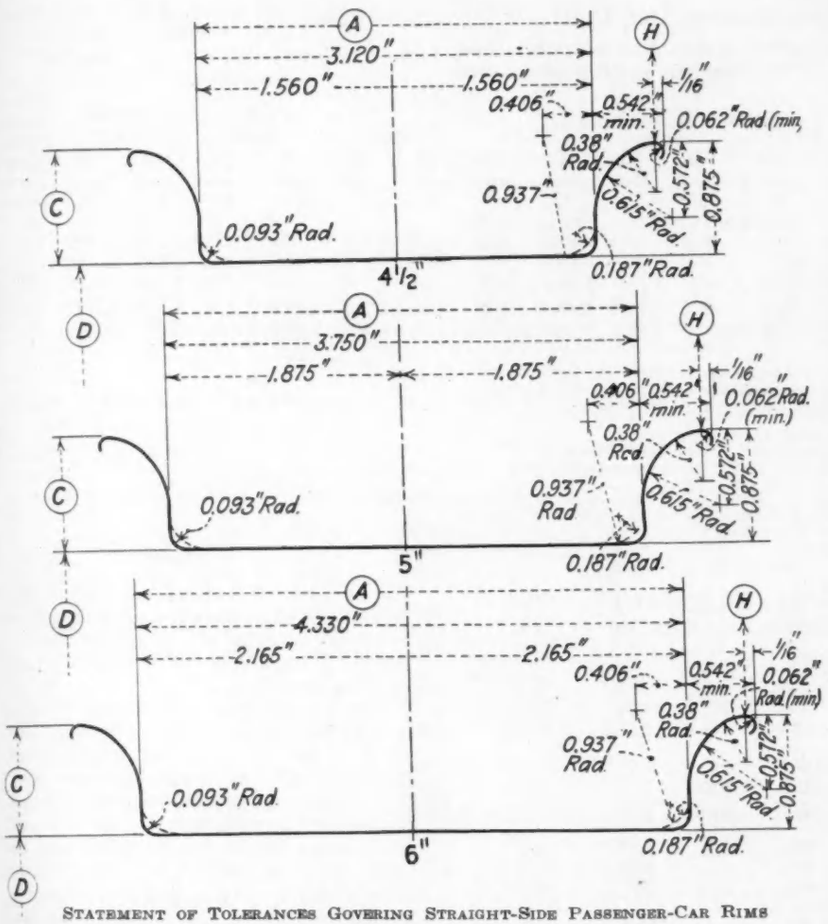
(Proposed S.A.E. Standard)

Rim Diameter, In.	Tire Sections							
	4.50	4.75	5.00	5.25	5.50	6.00	6.50	7.00
18				5.25–18	5.50–18 *(28x5.50)*	6.00–18 *(30x6.00)*	6.50–18 *(30x6.50)* *(30x6.20)*	7.00–18 *(32x7.00)* *(30x6.75)*
19		4.75–19	5.00–19 *(29x5.00)* *(28x4.95)*	5.25–19 *(29x5.25)*	5.50–19 *(29x5.50)*	6.00–19 *(31x6.00)*	6.50–19 *(31x6.50)* *(31x6.20)*	7.00–19
20		4.75–20 *(29x4.75)*	5.00–20 *(30x5.00)* *(29x4.95)*			6.00–20 *(32x6.00)* *(30x5.77)*	6.50–20 *(32x6.50)* *(32x6.20)*	7.00–20 *(34x7.00)* *(32x6.75)*
21	4.50–21							
Rim-Section Width,[1] In.	2.75 Flat Base or Drop	4	4	4	4	4½	4½	5
Maximum Tire Width on Rim, In.	4.75	4.85	5.15	5.35	5.60	5.95	6.40	6.90

[1] Rim widths given are nominal except the 2.75-in. size, which dimension is the actual width between flanges.

Method of Marking.—Tire shall be marked with the tire cross-section followed by the rim diameter on which the tire shall be used; under which designation shall be placed, in small figures, the former name-size or sizes of the tires replaced.

Method of Marking for Balance.—Tires shall be marked for balance by means of a red dot or a ¼-in. square on the serial side of the casing just above the rim flange.



STATEMENT OF TOLERANCES GOVERING STRAIGHT-SIDE PASSENGER-CAR RIMS

Tolerance at (*A*) width, plus or minus 0.063 in.
Tolerance at (*C*) height of flange, plus 0.047 in. minus 0.016 in.
Tolerance at (*D*) circumference, plus or minus 0.047 in. except on Q. D. Rims. On the gutter side only the tolerance is plus 0.047 and minus 0.063 in.
Maximum allowable depressions in tire seat of rim $\frac{1}{32}$ in., except within an area $\frac{1}{2}$ in. from the side wall depressions may be not to exceed $\frac{1}{8}$ in.
Maximum allowable projections on tire seat of rim $\frac{1}{32}$ in. except if within area covered by valve bridge washer, projections may be not to exceed $\frac{1}{32}$ in.
(*H*) High point of curvature
Split rims must align within $\frac{1}{32}$ in. Split rims must close to within $\frac{1}{32}$ in.
Rivet heads may project not to exceed $\frac{1}{32}$ in. above the rim base, provided they are within an area not covered by the tire beads and are of the crowned type, and free from sharp edges.

(*Approved by Tire and Rim Association, Jan. 9, 1929*)

Cushion Tires

The Division recommends the addition of the specification on cushion tires as an S.A.E. Standard.

CUSHION TIRES, HOLLOW CENTER

(*Proposed S.A.E. Standard*)

Nominal Tire Size, In.	Fits Wheel Diameter, In.	Maximum Carrying Capacity per Tire, Lb.	Maximum Recommended Speed M.P.H. (See Note 4)
32x4	26	1,350	22
34x4	28	1,425	22
36x4	30	1,425	22
32x5	26	1,800	22
34x5	28	1,900	22
36x5	30	1,900	22
32x6	26	2,700	22
34x6	28	2,850	22
36x6	30	2,850	22
40x6	34	3,000	22
34x7	28	3,800	18
36x7	30	3,800	18
40x7	34	4,000	18
34x8	28	4,750	18
36x8	30	4,750	18
40x8	34	5,000	18
32x9	26	5,400	18
36x9	30	5,700	18
32x10	26	6,300	18
36x10	30	6,650	18
36x12	30	8,550	18

Sizes underlined are recommended for use on models equipped with this type of tire.
Note 1.—For dual tires use double the carrying capacity of corresponding singles.
Note 2.—Recommended carrying capacities and speeds are for vehicles equipped with springs.
Note. 3.—For highway service on Trucks, Tractors and Trailers.
Note 4.—Trailers and other vehicles without springs are limited to speeds of 6 m.p.h. when loaded and 12 m.p.h. when unloaded.

Passenger-Car Balloon Tires

As the 5.50-20 tire size is used but little, the Division recommends that the present S.A.E. Specification

TRUCK AND BUS HIGH-PRESSURE TIRE LOAD AND INFLATION TABLE

(*Proposed S.A.E. Recommended Practice*)

Minimum Inflation Pressure, Lb.	Tire Sections and Rim Diameters, In.														Minimum Inflation Pressure, Lb.
				—5—		—6—		—7—		—8—		—9—		—10—	
	3½	4	4½	20	24	20	24	20	24	20	24	20	24	20	24	
	Maximum Load per Tire in Pounds															
50	600															50
55	675	800														55
60	750	900	1,050													60
65		1,000	1,150	1,325	1,575											65
70			1,250	1,450	1,700	1,700										70
75				1,575[a]	1,825	1,825	2,125									75
80				1,700	1,950	1,950[b]	2,250	2,200	2,600							80
85						2,075	2,375	2,350	2,750	2,775	3,125					85
90						2,200	2,500	2,500	2,900	2,900	3,300	3,300	3,800			90
100								2,800	3,200	3,250	3,650	3,700	4,200	4,150	4,650	100
110										3,600	4,000	4,100	4,600	4,600	5,100	110
120												4,500	5,000	5,050	5,550	120
130														5,500	6,000	130

Underscoring denotes maximum recommended load.
[a] Maximum load for 6-ply tire only.
[b] Maximum load for 8-ply tire only.
Dual cords will carry twice the load of corresponding singles.
(Approved as Tire and Rim Association Standard, Dec. 14, 1928.)

PASSENGER-CAR BALLOON-TIRE LOAD AND INFLATION TABLE

(*Proposed S.A.E. Recommended Practice*)

Tire Sections and Rim Diameters

Minimum Inflation Pressure, Lb.	4.40 18 and 19	4.40 20 and 21	4.50 18 and 19	4.50 20 and 21	4.75 18 and 19	4.75 20 and 21	5.00 18 and 19	5.00 20 and 21	5.25 18 and 19	5.25 20 and 21	5.50 18 and 19	5.50 20 and 21	6.00 18 and 19	6.00 20 and 21	(6.20) 6.50 18 and 19	(6.20) 6.50 20 and 21	(6.75) 7.00 18 and 19	(6.75) 7.00 20 and 21	Minimum Inflation Pressure, Lb.
	Maximum Load per Tire in Pounds																		
28	610	650	650	700	700	745	745	815	815	880	880	925	1,000	1,075	1,075	1,140	1,200	1,300	28
30	660	700	700	750	750	800	800	870	870	940	940	1,000	1,075	1,155	1,155	1,230	1,300	1,400	30
32	710	750	750	800	800	855	855	925	925	1,000	1,000	1,075	1,150	1,240	1,240	1,320	1,400	1,500	32
34	760	800	800	850	850	910	910	980	980	1,060	1,060	1,150	1,225	1,320	1,320	1,410	1,500	1,600	34
36	810	850	850	900	900	965	965	1,035	1,035	1,120	1,120	1,225	1,300	1,400	1,400	1,500	1,600	1,700	36

Single-underscored figures denote maximum recommended loads for 4-ply tires.
Double-underscored figures denote maximum recommended loads for 6-ply tires.
Note 1.—In the above table the weights are based on average passenger load using 150 lb. as weight per passenger and calculated as follows:
All 2, 3, and 4-passenger cars, 2-passenger load (midway).
All 5-passenger cars, 3-passenger load (2 midway and 1 over rear axle).
All 7-passenger cars, 4-passenger load (2 midway and 2 over rear axle).
NOTE 2.—This table not to be used for buses or trucks.
Note 3.—To take care of front-wheel steering and tread-wear conditions, it is recommended that front tires be inflated to same or greater pressure as rear tires, depending on recommendations of car manufacturers.
Dual tires will carry twice the load of the corresponding single.
(Approved as Tire and Rim Association Standard.)

TRUCK AND BUS BALLOON-TIRE LOAD AND INFLATION TABLE

(*Proposed S.A.E. Recommended Practice*)

Minimum Inflation Pressure, Lb.	Tire Sections 7.00	7.50	8.25	9.00	9.75	10.50	Minimum Inflation Pressure, Lb.
	Maximum Load per Tire in Pounds						
45	1,500						45
50	1,700	1,957	2,250				50
55		2,200	2,525	2,900			55
60			2,800	3,200	3,600		60
65				3,500	3,900	4,400	65
70					4,200	4,700	70
75						5,000	75

Underscoring indicates maximum recommended loads.
Duals will carry twice the load of corresponding singles.
(Approved as Tire and Rim Association Standard, Dec. 14, 1928.)

on Balloon Tires and Rims for Passenger-Cars be revised to omit this size. Confirming the action at its meeting in January, the Division also recommends omission of the 4.75-19 and 5.25-18 tire sizes, and addition of the 7.00-19 size. The Standards Committee is also requested to approve addition to the table of a note on the method of marking tires for balance, to read:

Note.—Tires shall be marked for balance by means of a red dot or a ¼-in. square on the serial side of the casing just above the rim flange.

Pneumatic-Tire Rim Sections

As present data on pneumatic-tire rim sections, given as S.A.E. General Information on pp. 337 and 338 of the HANDBOOK are obsolete, the Division recommends cancellation of this data and approval by the Standards Committee, as an S.A.E. Standard, of the specifications of the Tire and Rim Association as shown in the table on Pneumatic-Tire Rim Sections.

Action on Parts and Fittings

Rivet and Bumper Specifications Revised—New Woodruff Key-Slot and Keyways Data Approved

THE PARTS and Fittings Division met on May 8 to take action on several Subdivision reports which had been completed and to consider various other subjects proposed for action by this Committee.

The following paragraphs record the action upon the various specifications. Those previously published as Subdivision reports are mentioned by reference only to THE JOURNAL pages on which they appeared, and the data not hitherto published are given in full.

Split and Tubular Rivets

The report of the Subdivision on Split and Tubular Rivets, which revises the present specifications on pp. 240 and 241 of the 1929 edition of the HANDBOOK, was printed under Standardization Activities in the February, 1929, issue of THE JOURNAL. This report embodies the addition of a large number of dimensions and tolerances not heretofore provided on split rivets and gives for the first time a comprehensive standard for this item.

The report was unanimously approved by the Division, as it was the opinion that the subject had been thoroughly studied by the Subdivision and the specification offered represented the results of a considerable amount of work which was of inestimable value to users of these classes of rivets. The Standards Committee will be requested to approve these specifications as an S.A.E. Standard.

Passenger-Car Bumpers

In the May issue of THE JOURNAL, under Standardization Activities, was printed the report of the Subdivision on Passenger - Car Bumpers revising heights of passenger-car bumpers and the method of measuring such heights.

This report was also approved by the Division for submission to the Standards Committee as a revision of the existing S.A.E. Standard on Passenger-Car Bumper Heights and a revision of the existing S.A.E. Recommended Practice on Passenger-Car Bumper Mountings.

Woodruff Keys, Key-Slots and Keyways

Since the adoption and publication of the S.A.E. Specification on Woodruff Keys, considerable more data have been submitted to the Parts and Fittings Division on keyways, height of key above shaft, and so forth. Additional figures on the dimensions of flat-bottom Woodruff keys also were submitted.

In addition to this material, a complete table of dimensions of key-slots, height of key above shaft, and keyways for each size of key mounted in the various shafts in which it can be used was considered, and as this material was held to be very desirable from a design standpoint, the Division

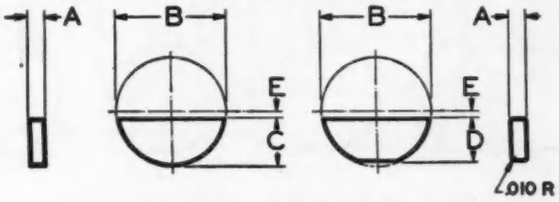
approved it as an addition to the present S.A.E. Standard.

Whereas the present specifications contain a column indicating a series of arbitrary numbers for keys, which numbering system is not in use, the Division decided it would be better to designate keys by actual dimensions.

The accompanying table gives the complete revised specification on Woodruff keys to include the flat-bottom type of key and the dimension *E*.

WOODRUFF KEYS

(Proposed Revision of S.A.E. Standard)



Optional Design

S.A.E. Nominal Size	"A" Width		"B" Diameter		"C" Height		"D" Height		"E" Height	Approx. Weight, lbs. per 1000
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Nom.	
1/16 x 1/2	.0625	.0635	.490	.500	.198	.203	.188	.194	3/64	1.3
3/32 x 1/2	.0938	.0948	.490	.500	.198	.203	.188	.194	3/64	1.9
1/8 x 1/2	.1250	.1260	.490	.500	.198	.203	.188	.194	3/64	2.5
3/32 x 5/8	.0938	.0948	.615	.625	.245	.250	.234	.240	1/16	3.0
1/8 x 5/8	.1250	.1260	.615	.625	.245	.250	.234	.240	1/16	3.9
5/32 x 5/8	.1563	.1573	.615	.625	.245	.250	.234	.240	1/16	4.9
1/8 x 3/4	.1250	.1260	.740	.750	.308	.313	.297	.303	1/16	6.1
5/32 x 3/4	.1563	.1573	.740	.750	.308	.313	.297	.303	1/16	7.5
3/16 x 3/4	.1875	.1885	.740	.750	.308	.313	.297	.303	1/16	9.0
5/32 x 7/8	.1563	.1573	.865	.875	.370	.375	.359	.365	1/16	11
3/16 x 7/8	.1875	.1885	.865	.875	.370	.375	.359	.365	1/16	13
1/4 x 7/8	.2500	.2510	.865	.875	.370	.375	.359	.365	1/16	17
3/16 x 1	.1875	.1885	.990	1.000	.433	.438	.422	.428	1/16	17
1/4 x 1	.2500	.2510	.990	1.000	.433	.438	.422	.428	1/16	23
5/16 x 1	.3125	.3135	.990	1.000	.433	.438	.422	.428	1/16	29
3/16 x 1 1/8	.1875	.1885	1.115	1.125	.479	.484	.469	.475	5/64	22
1/4 x 1 1/8	.2500	.2510	1.115	1.125	.479	.484	.469	.475	5/64	29
5/16 x 1 1/8	.3125	.3135	1.115	1.125	.479	.484	.469	.475	5/64	36
1/4 x 1 1/4	.2500	.2510	1.240	1.250	.542	.547	.531	.537	5/64	36
5/16 x 1 1/4	.3125	.3135	1.240	1.250	.542	.547	.531	.537	5/64	45
3/8 x 1 1/4	.3750	.3760	1.240	1.250	.542	.547	.531	.537	5/64	54
1/4 x 1 3/8	.2500	.2510	1.365	1.375	.589	.594	.578	.584	3/32	43
5/16 x 1 3/8	.3125	.3135	1.365	1.375	.589	.594	.578	.584	3/32	54
3/8 x 1 3/8	.3750	.3760	1.365	1.375	.589	.594	.578	.584	3/32	65
1/4 x 1 1/2	.2500	.2510	1.490	1.500	.636	.641	.625	.631	7/64	50
5/16 x 1 1/2	.3125	.3135	1.490	1.500	.636	.641	.625	.631	7/64	63
3/8 x 1 1/2	.3750	.3760	1.490	1.500	.636	.641	.625	.631	7/64	75

GENERAL SPECIFICATIONS

1. Width—A

Dimensions shown are set with the minimum key width as basic.
Tolerance on all key widths to be .001.
Maximum key width is basic plus tolerance.

2. Diameter—B

Dimensions shown are set with maximum diameter as basic. (American Standard)
Tolerance on all key diameters to be .010.
Minimum key diameter is basic minus tolerance.

3. Height—C

Dimensions shown are set with maximum height as basic. (American Standard)
Tolerance on all key heights to be .005.
Minimum key height is basic minus tolerance.

4. Height—D

Keys of this type are standard with some manufacturers. Dimensions shown have been furnished by those manufacturers.

5. Height—E

This dimension is given for convenience of draftsmen.

6. Weights

Weights shown are approximate.

7. Material

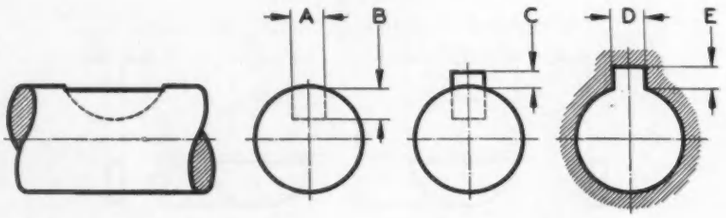
1035 steel or 2330 steel as specified. Keys of nickel steel are marked with depressions on the edges to distinguish them from carbon steel keys. Nickel steel keys are heat treated.

8. Manufacturer

Keys must be free from any defects that will affect their serviceability.

WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS

(Proposed Revision of S.A.E. Standard)



Woodruff Key Size	Keyslot					Key Above Shaft			Keyway					
	Width "A"			Depth "B"		Height "C"			Width "D"				Depth "E"	
									Class 2		Class 1		All Classes	
	Basic	Min.	Max.	Min.	Max.	Basic	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1/16 x 1/2	.0625	.0615	.0630	.1668	.1718	.0312	.0262	.0362	.0635	.0655	.0635	.0685	.0372	.0422
3/32 x 1/2	.0938	.0928	.0943	.1511	.1561	.0469	.0419	.0519	.0948	.0968	.0948	.0998	.0529	.0579
1/8 x 1/2	.1250	.1240	.1255	.1355	.1405	.0625	.0575	.0675	.1260	.1280	.1260	.1310	.0685	.0735
3/32 x 5/8	.0938	.0928	.0943	.1981	.2031	.0469	.0419	.0519	.0948	.0968	.0948	.0998	.0529	.0579
1/8 x 5/8	.1250	.1240	.1255	.1825	.1875	.0625	.0575	.0675	.1260	.1280	.1260	.1310	.0685	.0735
5/32 x 5/8	.1563	.1553	.1568	.1669	.1719	.0781	.0731	.0831	.1573	.1593	.1573	.1623	.0841	.0891
1/8 x 3/4	.1250	.1240	.1255	.2455	.2505	.0625	.0575	.0675	.1260	.1280	.1260	.1310	.0685	.0735
5/32 x 3/4	.1563	.1553	.1568	.2299	.2349	.0781	.0731	.0831	.1573	.1593	.1573	.1623	.0841	.0891
3/16 x 3/4	.1875	.1863	.1880	.2143	.2193	.0937	.0887	.0987	.1885	.1905	.1885	.1935	.0997	.1047
5/32 x 7/8	.1563	.1553	.1568	.2919	.2969	.0781	.0731	.0831	.1573	.1593	.1573	.1623	.0841	.0891
3/16 x 7/8	.1875	.1863	.1880	.2763	.2813	.0937	.0887	.0987	.1885	.1905	.1885	.1935	.0997	.1047
1/4 x 7/8	.2500	.2487	.2505	.2450	.2500	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
3/16 x 1	.1875	.1863	.1880	.3393	.3443	.0937	.0887	.0987	.1885	.1905	.1885	.1935	.0997	.1047
1/4 x 1	.2500	.2487	.2505	.3080	.3130	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
5/16 x 1	.3125	.3111	.3130	.2768	.2818	.1562	.1512	.1612	.3135	.3155	.3135	.3185	.1622	.1672
3/16 x 1 1/8	.1875	.1863	.1880	.3853	.3903	.0937	.0887	.0987	.1885	.1905	.1885	.1935	.0997	.1047
1/4 x 1 1/8	.2500	.2487	.2505	.3540	.3590	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
5/16 x 1 1/8	.3125	.3111	.3130	.3228	.3278	.1562	.1512	.1612	.3135	.3155	.3135	.3185	.1622	.1672
1/4 x 1 1/4	.2500	.2487	.2505	.4170	.4220	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
5/16 x 1 1/4	.3125	.3111	.3130	.3858	.3908	.1562	.1512	.1612	.3135	.3155	.3135	.3185	.1622	.1672
3/8 x 1 1/4	.3750	.3735	.3755	.3545	.3595	.1875	.1825	.1925	.3760	.3780	.3760	.3810	.1935	.1985
1/4 x 1 3/8	.2500	.2487	.2505	.4640	.4690	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
5/16 x 1 3/8	.3125	.3111	.3130	.4328	.4378	.1562	.1512	.1612	.3135	.3155	.3135	.3185	.1622	.1672
3/8 x 1 3/8	.3750	.3735	.3755	.4015	.4065	.1875	.1825	.1925	.3760	.3780	.3760	.3810	.1935	.1985
1/4 x 1 1/2	.2500	.2487	.2505	.5110	.5160	.1250	.1200	.1300	.2510	.2530	.2510	.2560	.1310	.1360
5/16 x 1 1/2	.3125	.3111	.3130	.4798	.4848	.1562	.1512	.1612	.3135	.3155	.3135	.3185	.1622	.1672
3/8 x 1 1/2	.3750	.3735	.3755	.4485	.4535	.1875	.1825	.1925	.3760	.3780	.3760	.3810	.1935	.1985

GENERAL SPECIFICATIONS

Keyslot

1. Width—A

Dimensions shown are set with the maximum keyslot width as that figure which will receive a key with the greatest amount of looseness permissible to assure the key sticking in the slot.

Minimum keyslot width is that figure permitting the largest shaft distortion acceptable when assembling maximum key in minimum keyslot.

The largest shaft distortion acceptable in all calculations was **.0003** not more than **3/16"** from side of assembled key.

2. Depth—B

Dimensions shown are set with the maximum as that figure which receives a key of maximum height and permits the key to project above the shaft a distance equal to one half the basic width. Tolerance on all keyslot depths **.005.** Minimum keyslot depth is maximum minus tolerance.

3. Note:

The word "depth" as applied to "keyslot" should be construed to mean the depth of the keyslot taken at the side.

Key Above Shaft

4. Height—C

Dimensions shown are set with one half the basic key as basic height. Tolerance on key height above shaft plus or minus **.005.**

5. Note:

The wording "key above shaft" and "height" should be construed to mean the amount of key exposed after being fitted into place.

Keyway

6. Width—D

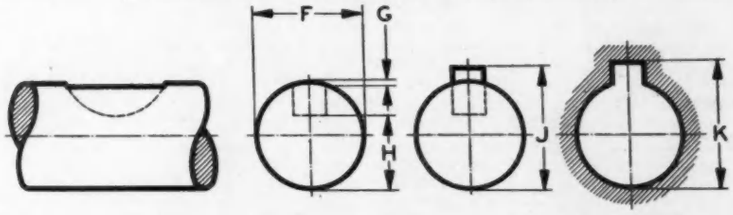
Dimensions shown are determined by using for width of keyway, the maximum width of key minus **.000,** plus **.002** for Class **2** and minus **.000,** plus **.005** for Class **1.**

7. Depth—E

Dimensions shown are determined by using for depth of keyway, the maximum key in the minimum keyslot plus **.001,** plus **.006.**

Details of Woodruff Keyslot, Key Above Shaft and Keyway Standards

(Proposed Revision of S.A.E. Standard)



Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
1/16 x 1/2	5/16	.3125	.0032	.1375	.1425	.3355	.3455	.3465	.3515
	11/32	.3437	.0029	.1690	.1740	.3670	.3770	.3780	.3830
	3/8	.3750	.0026	.2006	.2056	.3986	.4086	.4096	.4146
	13/32	.4062	.0024	.2320	.2370	.4300	.4400	.4410	.4460
	7/16	.4375	.0022	.2635	.2685	.4615	.4715	.4725	.4775
	15/32	.4687	.0021	.2948	.2998	.4928	.5028	.5038	.5088
	1/2	.5000	.0020	.3262	.3312	.5242	.5342	.5352	.5402
3/32 x 1/2	11/32	.3437	.0065	.1811	.1861	.3791	.3891	.3901	.3951
	3/8	.3750	.0060	.2129	.2179	.4109	.4209	.4219	.4269
	13/32	.4062	.0055	.2446	.2496	.4426	.4526	.4536	.4586
	7/16	.4375	.0051	.2763	.2813	.4743	.4843	.4853	.4903
	15/32	.4687	.0047	.3079	.3129	.5059	.5159	.5169	.5219
	1/2	.5000	.0044	.3395	.3445	.5375	.5475	.5485	.5535
	9/16	.5625	.0039	.4025	.4075	.6005	.6105	.6115	.6165
	5/8	.6250	.0035	.4654	.4704	.6634	.6734	.6744	.6794
1/8 x 1/2	3/8	.3750	.0107	.2238	.2288	.4218	.4318	.4328	.4378
	13/32	.4062	.0099	.2558	.2608	.4538	.4638	.4648	.4698
	7/16	.4375	.0091	.2879	.2929	.4859	.4959	.4969	.5019
	15/32	.4687	.0085	.3197	.3247	.5177	.5277	.5287	.5337
	1/2	.5000	.0079	.3516	.3566	.5496	.5596	.5606	.5656
	9/16	.5625	.0070	.4150	.4200	.6130	.6230	.6240	.6290
	5/8	.6250	.0063	.4782	.4832	.6762	.6862	.6872	.6922
	11/16	.6875	.0057	.5413	.5463	.7393	.7493	.7503	.7553
	3/4	.7500	.0052	.6043	.6093	.8023	.8123	.8133	.8183
3/32 x 5/8	13/32	.4062	.0055	.1976	.2026	.4426	.4526	.4536	.4586
	7/16	.4375	.0051	.2293	.2343	.4743	.4843	.4853	.4903
	15/32	.4687	.0047	.2609	.2659	.5059	.5159	.5169	.5219
	1/2	.5000	.0044	.2925	.2975	.5375	.5475	.5485	.5535
	9/16	.5625	.0039	.3555	.3605	.6005	.6105	.6115	.6165
	5/8	.6250	.0035	.4184	.4234	.6634	.6734	.6744	.6794
	11/16	.6875	.0032	.4812	.4862	.7262	.7362	.7372	.7422
	3/4	.7500	.0029	.5440	.5490	.7890	.7990	.8000	.8050
	13/16	.8125	.0027	.6067	.6117	.8517	.8617	.8627	.8677
	7/8	.8750	.0025	.6694	.6744	.9144	.9244	.9254	.9304
1/8 x 5/8	7/16	.4375	.0091	.2409	.2459	.4859	.4959	.4969	.5019
	15/32	.4687	.0085	.2727	.2777	.5177	.5277	.5287	.5337
	1/2	.5000	.0079	.3046	.3096	.5496	.5596	.5606	.5656
	9/16	.5625	.0070	.3680	.3730	.6130	.6230	.6240	.6290
	5/8	.6250	.0063	.4312	.4362	.6762	.6862	.6872	.6922
	11/16	.6875	.0057	.4943	.4993	.7393	.7493	.7503	.7553
	3/4	.7500	.0052	.5573	.5623	.8023	.8123	.8133	.8183
	13/16	.8125	.0048	.6202	.6252	.8652	.8752	.8762	.8812
	7/8	.8750	.0045	.6830	.6880	.9280	.9380	.9390	.9440
	15/16	.9375	.0042	.7458	.7508	.9908	1.0008	1.0018	1.0068
	1	1.0000	.0039	.8086	.8136	1.0536	1.0636	1.0646	1.0696
5/32 x 5/8	15/32	.4687	.0134	.2834	.2884	.5284	.5384	.5394	.5444
	1/2	.5000	.0125	.3156	.3206	.5606	.5706	.5716	.5766
	9/16	.5625	.0111	.3795	.3845	.6245	.6345	.6355	.6405
	5/8	.6250	.0099	.4432	.4482	.6882	.6982	.6992	.7042

The table on key-slots, height of key above shafts, and keyways represents the revision of similar material in the present standard by the addition of the table on dimensions of keyways.

The complete table on key-slots, height of key above shaft, and keyways for various-size keys in various sizes of shafting is published on this and the following pages.

The entire specifications as printed herewith will be submitted to the Standards Committee for approval as the S.A.E. Standard on Woodruff Keys, Key-Slots and Keyways.

DETAILS OF WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS (*Continued*)

Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
5/32 x 5/8	11/16	.6875	.0090	.5066	.5116	.7516	.7616	.7626	.7676
	3/4	.7500	.0082	.5699	.5749	.8149	.8249	.8259	.8309
	13/16	.8125	.0076	.6330	.6380	.8780	.8880	.8890	.8940
	7/8	.8750	.0070	.6961	.7011	.9411	.9511	.9521	.9571
	15/16	.9375	.0066	.7590	.7640	1.0040	1.0140	1.0150	1.0200
	1	1.0000	.0061	.8220	.8270	1.0670	1.0770	1.0780	1.0830
	1 1/16	1.0625	.0058	.8848	.8898	1.1298	1.1398	1.1408	1.1458
	1 1/8	1.1250	.0055	.9476	.9526	1.1926	1.2026	1.2036	1.2086
1/8 x 3/4	1/2	.5000	.0079	.2416	.2466	.5496	.5596	.5606	.5656
	9/16	.5625	.0070	.3050	.3100	.6130	.6230	.6240	.6290
	5/8	.6250	.0063	.3682	.3732	.6762	.6862	.6872	.6922
	11/16	.6875	.0057	.4313	.4363	.7393	.7493	.7503	.7553
	3/4	.7500	.0052	.4943	.4993	.8023	.8123	.8133	.8183
	13/16	.8125	.0048	.5572	.5622	.8652	.8752	.8762	.8812
	7/8	.8750	.0045	.6200	.6250	.9280	.9380	.9390	.9440
	15/16	.9375	.0042	.6828	.6878	.9908	1.0008	1.0018	1.0068
	1	1.0000	.0039	.7456	.7506	1.0536	1.0636	1.0646	1.0696
	1 1/16	1.0625	.0037	.8083	.8133	1.1163	1.1263	1.1273	1.1323
	1 1/8	1.1250	.0035	.8710	.8760	1.1790	1.1890	1.1900	1.1950
	1 3/16	1.1875	.0033	.9337	.9387	1.2417	1.2517	1.2527	1.2577
	1 1/4	1.2500	.0031	.9964	1.0014	1.3044	1.3144	1.3154	1.3204
5/32 x 3/4	9/16	.5625	.0111	.3165	.3215	.6245	.6345	.6355	.6405
	5/8	.6250	.0099	.3802	.3852	.6882	.6982	.6992	.7042
	11/16	.6875	.0090	.4436	.4486	.7516	.7616	.7626	.7676
	3/4	.7500	.0082	.5069	.5119	.8149	.8249	.8259	.8309
	13/16	.8125	.0076	.5700	.5750	.8780	.8880	.8890	.8940
	7/8	.8750	.0070	.6331	.6381	.9411	.9511	.9521	.9571
	15/16	.9375	.0066	.6960	.7010	1.0040	1.0140	1.0150	1.0200
	1	1.0000	.0061	.7590	.7640	1.0670	1.0770	1.0780	1.0830
	1 1/16	1.0625	.0058	.8218	.8268	1.1298	1.1398	1.1408	1.1458
	1 1/8	1.1250	.0055	.8846	.8896	1.1926	1.2026	1.2036	1.2086
	1 3/16	1.1875	.0052	.9474	.9524	1.2554	1.2654	1.2664	1.2714
	1 1/4	1.2500	.0049	1.0102	1.0152	1.3182	1.3282	1.3292	1.3342
	1 3/8	1.3750	.0045	1.1356	1.1406	1.4436	1.4536	1.4546	1.4596
3/16 x 3/4	9/16	.5625	.0161	.3271	.3321	.6351	.6451	.6461	.6511
	5/8	.6250	.0144	.3913	.3963	.6993	.7093	.7103	.7153
	11/16	.6875	.0130	.4552	.4602	.7632	.7732	.7742	.7792
	3/4	.7500	.0119	.5188	.5238	.8268	.8368	.8378	.8428
	13/16	.8125	.0110	.5822	.5872	.8902	.9002	.9012	.9062
	7/8	.8750	.0102	.6455	.6505	.9535	.9635	.9645	.9695
	15/16	.9375	.0095	.7087	.7137	1.0167	1.0267	1.0277	1.0327
	1	1.0000	.0089	.7718	.7768	1.0798	1.0898	1.0908	1.0958
	1 1/16	1.0625	.0083	.8349	.8399	1.1429	1.1529	1.1539	1.1589
	1 1/8	1.1250	.0079	.8978	.9028	1.2058	1.2158	1.2168	1.2218
	1 3/16	1.1875	.0074	.9608	.9658	1.2688	1.2788	1.2798	1.2848
	1 1/4	1.2500	.0071	1.0236	1.0286	1.3316	1.3416	1.3426	1.3476
	1 3/8	1.3750	.0064	1.1493	1.1543	1.4573	1.4673	1.4683	1.4733
	1 1/2	1.5000	.0059	1.2748	1.2798	1.5828	1.5928	1.5938	1.5988
5/32 x 7/8	5/8	.6250	.0099	.3182	.3232	.6882	.6982	.6992	.7042
	11/16	.6875	.0090	.3816	.3866	.7516	.7616	.7626	.7676
	3/4	.7500	.0082	.4449	.4499	.8149	.8249	.8259	.8309
	13/16	.8125	.0076	.5080	.5130	.8780	.8880	.8890	.8940
	7/8	.8750	.0070	.5711	.5761	.9411	.9511	.9521	.9571
	15/16	.9375	.0066	.6340	.6390	1.0040	1.0140	1.0150	1.0200
	1	1.0000	.0061	.6970	.7020	1.0670	1.0770	1.0780	1.0830
	1 1/16	1.0625	.0058	.7598	.7648	1.1298	1.1398	1.1408	1.1458
	1 1/8	1.1250	.0055	.8226	.8276	1.1926	1.2026	1.2036	1.2086
	1 3/16	1.1875	.0052	.8854	.8904	1.2554	1.2654	1.2664	1.2714
	1 1/4	1.2500	.0049	.9482	.9532	1.3182	1.3282	1.3292	1.3342
	1 3/8	1.3750	.0045	1.0736	1.0786	1.4436	1.4536	1.4546	1.4596
	1 1/2	1.5000	.0041	1.1990	1.2040	1.5690	1.5790	1.5800	1.5850
	1 5/8	1.6250	.0038	1.3243	1.3293	1.6943	1.7043	1.7053	1.7103

DETAILS OF WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS (*Continued*)

Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
3/16 x 7/8	5/8	.6250	.0144	.3293	.3343	.6993	.7093	.7103	.7153
	11/16	.6875	.0130	.3932	.3982	.7632	.7732	.7742	.7792
	3/4	.7500	.0119	.4568	.4618	.8268	.8368	.8378	.8428
	13/16	.8125	.0110	.5202	.5252	.8902	.9002	.9012	.9062
	7/8	.8750	.0102	.5835	.5885	.9535	.9635	.9645	.9695
	15/16	.9375	.0095	.6467	.6517	1.0167	1.0267	1.0277	1.0327
	1	1.0000	.0089	.7098	.7148	1.0798	1.0898	1.0908	1.0958
	1 1/16	1.0625	.0083	.7729	.7779	1.1429	1.1529	1.1539	1.1589
	1 1/8	1.1250	.0079	.8358	.8408	1.2058	1.2158	1.2168	1.2218
	1 3/16	1.1875	.0074	.8988	.9038	1.2688	1.2788	1.2798	1.2848
	1 1/4	1.2500	.0071	.9616	.9666	1.3316	1.3416	1.3426	1.3476
	1 3/8	1.3750	.0064	1.0873	1.0923	1.4573	1.4673	1.4683	1.4733
	1 1/2	1.5000	.0059	1.2128	1.2178	1.5828	1.5928	1.5938	1.5988
	1 5/8	1.6250	.0054	1.3383	1.3433	1.7083	1.7183	1.7193	1.7243
	1 3/4	1.7500	.0050	1.4637	1.4687	1.8337	1.8437	1.8447	1.8497
1/4 x 7/8	11/16	.6875	.0235	.4140	.4190	.7840	.7940	.7950	.8000
	3/4	.7500	.0214	.4786	.4836	.8486	.8586	.8596	.8646
	13/16	.8125	.0197	.5428	.5478	.9128	.9228	.9238	.9288
	7/8	.8750	.0182	.6068	.6118	.9768	.9868	.9878	.9928
	15/16	.9375	.0170	.6705	.6755	1.0405	1.0505	1.0515	1.0565
	1	1.0000	.0159	.7341	.7391	1.1041	1.1141	1.1151	1.1201
	1 1/16	1.0625	.0149	.7976	.8026	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.8609	.8659	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.9242	.9292	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.9874	.9924	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	1.1135	1.1185	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	1.2395	1.2445	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.3653	1.3703	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.4910	1.4960	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.6166	1.6216	1.9866	1.9966	1.9976	2.0026
3/16 x 1	11/16	.6875	.0130	.3302	.3352	.7632	.7732	.7742	.7792
	3/4	.7500	.0119	.3938	.3988	.8268	.8368	.8378	.8428
	13/16	.8125	.0110	.4572	.4622	.8902	.9002	.9012	.9062
	7/8	.8750	.0102	.5205	.5255	.9535	.9635	.9645	.9695
	15/16	.9375	.0095	.5837	.5887	1.0167	1.0267	1.0277	1.0327
	1	1.0000	.0089	.6468	.6518	1.0798	1.0898	1.0908	1.0958
	1 1/16	1.0625	.0083	.7099	.7149	1.1429	1.1529	1.1539	1.1589
	1 1/8	1.1250	.0079	.7728	.7778	1.2058	1.2158	1.2168	1.2218
	1 3/16	1.1875	.0074	.8358	.8408	1.2688	1.2788	1.2798	1.2848
	1 1/4	1.2500	.0071	.8986	.9036	1.3316	1.3416	1.3426	1.3476
	1 3/8	1.3750	.0064	1.0243	1.0293	1.4573	1.4673	1.4683	1.4733
	1 1/2	1.5000	.0059	1.1498	1.1548	1.5828	1.5928	1.5938	1.5988
	1 5/8	1.6250	.0054	1.2753	1.2803	1.7083	1.7183	1.7193	1.7243
	1 3/4	1.7500	.0050	1.4007	1.4057	1.8337	1.8437	1.8447	1.8497
	1 7/8	1.8750	.0047	1.5260	1.5310	1.9590	1.9690	1.9700	1.9750
	2	2.0000	.0044	1.6513	1.6563	2.0843	2.0943	2.0953	2.1003
1/4 x 1	3/4	.7500	.0214	.4156	.4206	.8486	.8586	.8596	.8646
	13/16	.8125	.0197	.4798	.4848	.9128	.9228	.9238	.9288
	7/8	.8750	.0182	.5438	.5488	.9768	.9868	.9878	.9928
	15/16	.9375	.0170	.6075	.6125	1.0405	1.0505	1.0515	1.0565
	1	1.0000	.0159	.6711	.6761	1.1041	1.1141	1.1151	1.1201
	1 1/16	1.0625	.0149	.7346	.7396	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.7979	.8029	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.8612	.8662	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.9244	.9294	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	1.0505	1.0555	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	1.1765	1.1815	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.3023	1.3073	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.4280	1.4330	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.5536	1.5586	1.9866	1.9966	1.9976	2.0026
	2	2.0000	.0078	1.6792	1.6842	2.1122	2.1222	2.1232	2.1282
5/16 x 1	3/4	.7500	.0341	.4341	.4391	.8671	.8771	.8781	.8831
	13/16	.8125	.0312	.4995	.5045	.9325	.9425	.9435	.9485
	7/8	.8750	.0288	.5644	.5694	.9974	1.0074	1.0084	1.0134
	15/16	.9375	.0268	.6289	.6339	1.0619	1.0719	1.0729	1.0779

DETAILS OF WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS (*Continued*)

Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
5/16 x 1	1	1.0000	.0250	.6932	.6982	1.1262	1.1362	1.1372	1.1422
	1 1/16	1.0625	.0235	.7572	.7622	1.1902	1.2002	1.2012	1.2062
	1 1/8	1.1250	.0221	.8211	.8261	1.2541	1.2641	1.2651	1.2701
	1 3/16	1.1875	.0209	.8848	.8898	1.3178	1.3278	1.3288	1.3338
	1 1/4	1.2500	.0198	.9484	.9534	1.3814	1.3914	1.3924	1.3974
	1 3/8	1.3750	.0180	1.0752	1.0802	1.5082	1.5182	1.5192	1.5242
	1 1/2	1.5000	.0165	1.2017	1.2067	1.6347	1.6447	1.6457	1.6507
	1 5/8	1.6250	.0152	1.3280	1.3330	1.7610	1.7710	1.7720	1.7770
	1 3/4	1.7500	.0141	1.4541	1.4591	1.8871	1.8971	1.8981	1.9031
	1 7/8	1.8750	.0131	1.5801	1.5851	2.0131	2.0231	2.0241	2.0291
	2	2.0000	.0123	1.7059	1.7109	2.1389	2.1489	2.1499	2.1549
3/16 x 1 1/8	13/16	.8125	.0110	.4112	.4162	.8902	.9002	.9012	.9062
	7/8	.8750	.0102	.4745	.4795	.9535	.9635	.9645	.9695
	15/16	.9375	.0095	.5377	.5427	1.0167	1.0267	1.0277	1.0327
	1	1.0000	.0089	.6008	.6058	1.0798	1.0898	1.0908	1.0958
	1 1/16	1.0625	.0083	.6639	.6689	1.1429	1.1529	1.1539	1.1589
	1 1/8	1.1250	.0079	.7268	.7318	1.2058	1.2158	1.2168	1.2218
	1 3/16	1.1875	.0074	.7898	.7948	1.2688	1.2788	1.2798	1.2848
	1 1/4	1.2500	.0071	.8526	.8576	1.3316	1.3416	1.3426	1.3476
	1 3/8	1.3750	.0064	.9783	.9833	1.4573	1.4673	1.4683	1.4733
	1 1/2	1.5000	.0059	1.1038	1.1088	1.5828	1.5928	1.5938	1.5988
	1 5/8	1.6250	.0054	1.2293	1.2343	1.7083	1.7183	1.7193	1.7243
	1 3/4	1.7500	.0050	1.3547	1.3597	1.8337	1.8437	1.8447	1.8497
	1 7/8	1.8750	.0047	1.4800	1.4850	1.9590	1.9690	1.9700	1.9750
	2	2.0000	.0044	1.6053	1.6103	2.0843	2.0943	2.0953	2.1003
1/4 x 1 1/8	13/16	.8125	.0197	.4338	.4388	.9128	.9228	.9238	.9288
	7/8	.8750	.0182	.4978	.5028	.9768	.9868	.9878	.9928
	15/16	.9375	.0170	.5615	.5665	1.0405	1.0505	1.0515	1.0565
	1	1.0000	.0159	.6251	.6301	1.1041	1.1141	1.1151	1.1201
	1 1/16	1.0625	.0149	.6886	.6936	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.7519	.7569	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.8152	.8202	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.8784	.8834	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	1.0045	1.0095	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	1.1305	1.1355	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.2563	1.2613	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.3820	1.3870	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.5076	1.5126	1.9866	1.9966	1.9976	2.0026
	2	2.0000	.0078	1.6332	1.6382	2.1122	2.1222	2.1232	2.1282
5/16 x 1 1/8	7/8	.8750	.0288	.5184	.5234	.9974	1.0074	1.0084	1.0134
	15/16	.9375	.0268	.5829	.5879	1.0619	1.0719	1.0729	1.0779
	1	1.0000	.0250	.6472	.6522	1.1262	1.1362	1.1372	1.1422
	1 1/16	1.0625	.0235	.7112	.7162	1.1902	1.2002	1.2012	1.2062
	1 1/8	1.1250	.0221	.7751	.7801	1.2541	1.2641	1.2651	1.2701
	1 3/16	1.1875	.0209	.8388	.8438	1.3178	1.3278	1.3288	1.3338
	1 1/4	1.2500	.0198	.9024	.9074	1.3814	1.3914	1.3924	1.3974
	1 3/8	1.3750	.0180	1.0292	1.0342	1.5082	1.5182	1.5192	1.5242
	1 1/2	1.5000	.0165	1.1557	1.1607	1.6347	1.6447	1.6457	1.6507
	1 5/8	1.6250	.0152	1.2820	1.2870	1.7610	1.7710	1.7720	1.7770
	1 3/4	1.7500	.0141	1.4081	1.4131	1.8871	1.8971	1.8981	1.9031
	1 7/8	1.8750	.0131	1.5341	1.5391	2.0131	2.0231	2.0241	2.0291
	2	2.0000	.0123	1.6599	1.6649	2.1389	2.1489	2.1499	2.1549
1/4 x 1 1/4	7/8	.8750	.0182	.4348	.4398	.9768	.9868	.9878	.9928
	15/16	.9375	.0170	.4985	.5035	1.0405	1.0505	1.0515	1.0565
	1	1.0000	.0159	.5621	.5671	1.1041	1.1141	1.1151	1.1201
	1 1/16	1.0625	.0149	.6256	.6306	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.6889	.6939	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.7522	.7572	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.8154	.8204	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	.9415	.9465	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	1.0675	1.0725	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.1933	1.1983	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.3190	1.3240	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.4446	1.4496	1.9866	1.9966	1.9976	2.0026
	2	2.0000	.0078	1.5702	1.5752	2.1122	2.1222	2.1232	2.1282

DETAILS OF WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS (*Continued*)

Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
5/16 x 1 1/4	15/16	.9375	.0268	.5199	.5249	1.0619	1.0719	1.0729	1.0779
	1	1.0000	.0250	.5842	.5892	1.1262	1.1362	1.1372	1.1422
	1 1/16	1.0625	.0235	.6482	.6532	1.1902	1.2002	1.2012	1.2062
	1 1/8	1.1250	.0221	.7121	.7171	1.2541	1.2641	1.2651	1.2701
	1 3/16	1.1875	.0209	.7758	.7808	1.3178	1.3278	1.3288	1.3338
	1 1/4	1.2500	.0198	.8394	.8444	1.3814	1.3914	1.3924	1.3974
	1 3/8	1.3750	.0180	.9662	.9712	1.5082	1.5182	1.5192	1.5242
	1 1/2	1.5000	.0165	1.0927	1.0977	1.6347	1.6447	1.6457	1.6507
	1 5/8	1.6250	.0152	1.2190	1.2240	1.7610	1.7710	1.7720	1.7770
	1 3/4	1.7500	.0141	1.3451	1.3501	1.8871	1.8971	1.8981	1.9031
	1 7/8	1.8750	.0131	1.4711	1.4761	2.0131	2.0231	2.0241	2.0291
	2	2.0000	.0123	1.5969	1.6019	2.1389	2.1489	2.1499	2.1549
3/8 x 1 1/4	15/16	.9375	.0391	.5389	.5439	1.0809	1.0909	1.0919	1.0969
	1	1.0000	.0365	.6040	.6090	1.1460	1.1560	1.1570	1.1620
	1 1/16	1.0625	.0342	.6688	.6738	1.2108	1.2208	1.2218	1.2268
	1 1/8	1.1250	.0322	.7333	.7383	1.2753	1.2853	1.2863	1.2913
	1 3/16	1.1875	.0304	.7976	.8026	1.3396	1.3496	1.3506	1.3556
	1 1/4	1.2500	.0288	.8617	.8667	1.4037	1.4137	1.4147	1.4197
	1 3/8	1.3750	.0261	.9894	.9944	1.5314	1.5414	1.5424	1.5474
	1 1/2	1.5000	.0238	1.1167	1.1217	1.6587	1.6687	1.6697	1.6747
	1 5/8	1.6250	.0219	1.2436	1.2486	1.7856	1.7956	1.7966	1.8016
	1 3/4	1.7500	.0203	1.3702	1.3752	1.9122	1.9222	1.9232	1.9282
	1 7/8	1.8750	.0189	1.4966	1.5016	2.0386	2.0486	2.0496	2.0546
	2	2.0000	.0177	1.6228	1.6278	2.1648	2.1748	2.1758	2.1808
1/4 x 1 3/8	1	1.0000	.0159	.5151	.5201	1.1041	1.1141	1.1151	1.1201
	1 1/16	1.0625	.0149	.5786	.5836	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.6419	.6469	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.7052	.7102	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.7684	.7734	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	.8945	.8995	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	1.0205	1.0255	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.1463	1.1513	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.2720	1.2770	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.3976	1.4026	1.9866	1.9966	1.9976	2.0026
	2	2.0000	.0078	1.5232	1.5282	2.1122	2.1222	2.1232	2.1282
5/16 x 1 3/8	1	1.0000	.0250	.5372	.5422	1.1262	1.1362	1.1372	1.1422
	1 1/16	1.0625	.0235	.6012	.6062	1.1902	1.2002	1.2012	1.2062
	1 1/8	1.1250	.0221	.6651	.6701	1.2541	1.2641	1.2651	1.2701
	1 3/16	1.1875	.0209	.7288	.7338	1.3178	1.3278	1.3288	1.3338
	1 1/4	1.2500	.0198	.7924	.7974	1.3814	1.3914	1.3924	1.3974
	1 3/8	1.3750	.0180	.9192	.9242	1.5082	1.5182	1.5192	1.5242
	1 1/2	1.5000	.0165	1.0457	1.0507	1.6347	1.6447	1.6457	1.6507
	1 5/8	1.6250	.0152	1.1720	1.1770	1.7610	1.7710	1.7720	1.7770
	1 3/4	1.7500	.0141	1.2981	1.3031	1.8871	1.8971	1.8981	1.9031
	1 7/8	1.8750	.0131	1.4241	1.4291	2.0131	2.0231	2.0241	2.0291
	2	2.0000	.0123	1.5499	1.5549	2.1389	2.1489	2.1499	2.1549
3/8 x 1 3/8	1 1/16	1.0625	.0342	.6218	.6268	1.2108	1.2208	1.2218	1.2268
	1 1/8	1.1250	.0322	.6863	.6913	1.2753	1.2853	1.2863	1.2913
	1 3/16	1.1875	.0304	.7506	.7556	1.3396	1.3496	1.3506	1.3556
	1 1/4	1.2500	.0288	.8147	.8197	1.4037	1.4137	1.4147	1.4197
	1 3/8	1.3750	.0261	.9424	.9474	1.5314	1.5414	1.5424	1.5474
	1 1/2	1.5000	.0238	1.0697	1.0747	1.6587	1.6687	1.6697	1.6747
	1 5/8	1.6250	.0219	1.1966	1.2016	1.7856	1.7956	1.7966	1.8016
	1 3/4	1.7500	.0203	1.3232	1.3282	1.9122	1.9222	1.9232	1.9282
	1 7/8	1.8750	.0189	1.4496	1.4546	2.0386	2.0486	2.0496	2.0546
	2	2.0000	.0177	1.5758	1.5808	2.1648	2.1748	2.1758	2.1808

DETAILS OF WOODRUFF KEYSLOT, KEY ABOVE SHAFT AND KEYWAY STANDARDS—(*Concluded*)

Woodruff Key Size	Shaft Diameter F		Versed Sine	Bottom of Keyslot to Opposite Side of Shaft H		Top of Key to Opposite Side of Shaft J		Bottom of Keyway to Opposite Side of Bore K	
	Frac.	Dec.	G	Min.	Max.	Min.	Max.	Min.	Max.
¼ x 1½	1 1/16	1.0625	.0149	.5316	.5366	1.1676	1.1776	1.1786	1.1836
	1 1/8	1.1250	.0141	.5949	.5999	1.2309	1.2409	1.2419	1.2469
	1 3/16	1.1875	.0133	.6582	.6632	1.2942	1.3042	1.3052	1.3102
	1 1/4	1.2500	.0126	.7214	.7264	1.3574	1.3674	1.3684	1.3734
	1 3/8	1.3750	.0115	.8475	.8525	1.4835	1.4935	1.4945	1.4995
	1 1/2	1.5000	.0105	.9735	.9785	1.6095	1.6195	1.6205	1.6255
	1 5/8	1.6250	.0097	1.0993	1.1043	1.7353	1.7453	1.7463	1.7513
	1 3/4	1.7500	.0090	1.2250	1.2300	1.8610	1.8710	1.8720	1.8770
	1 7/8	1.8750	.0084	1.3506	1.3556	1.9866	1.9966	1.9976	2.0026
	2	2.0000	.0078	1.4762	1.4812	2.1122	2.1222	2.1232	2.1282
5/16 x 1½	1 1/8	1.1250	.0221	.6181	.6231	1.2541	1.2641	1.2651	1.2701
	1 3/16	1.1875	.0209	.6818	.6868	1.3178	1.3278	1.3288	1.3338
	1 1/4	1.2500	.0198	.7454	.7504	1.3814	1.3914	1.3924	1.3974
	1 3/8	1.3750	.0180	.8722	.8772	1.5082	1.5182	1.5192	1.5242
	1 1/2	1.5000	.0165	.9987	1.0037	1.6347	1.6447	1.6457	1.6507
	1 5/8	1.6250	.0152	1.1250	1.1300	1.7610	1.7710	1.7720	1.7770
	1 3/4	1.7500	.0141	1.2511	1.2561	1.8871	1.8971	1.8981	1.9031
	1 7/8	1.8750	.0131	1.3771	1.3821	2.0131	2.0231	2.0241	2.0291
	2	2.0000	.0123	1.5029	1.5079	2.1389	2.1489	2.1499	2.1549
3/8 x 1½	1 1/8	1.1250	.0322	.6393	.6443	1.2753	1.2853	1.2863	1.2913
	1 3/16	1.1875	.0304	.7036	.7086	1.3396	1.3496	1.3506	1.3556
	1 1/4	1.2500	.0288	.7677	.7727	1.4037	1.4137	1.4147	1.4197
	1 3/8	1.3750	.0261	.8954	.9004	1.5314	1.5414	1.5424	1.5474
	1 1/2	1.5000	.0238	1.0227	1.0277	1.6587	1.6687	1.6697	1.6747
	1 5/8	1.6250	.0219	1.1496	1.1546	1.7856	1.7956	1.7966	1.8016
	1 3/4	1.7500	.0203	1.2762	1.2812	1.9122	1.9222	1.9232	1.9282
	1 7/8	1.8750	.0189	1.4026	1.4076	2.0386	2.0486	2.0496	2.0546
	2	2.0000	.0177	1.5288	1.5338	2.1648	2.1748	2.1758	2.1808

GENERAL SPECIFICATIONS

1. Shaft Diameter—F

Decimal equivalents are given to four places and all figures in the remaining columns are calculated from these basic dimensions. Any change in the shaft diameter from basic will necessarily change all other figures and, in this case, should accurate dimensions be required, the formula in the next paragraph should be used.

2. Versed Sine—G

The versed sines specified are determined from the following formula.

$$G = \frac{F}{2} - \sqrt{\frac{F^2 - A^2}{4}}$$

"A" being the basic width of the keyslot.

3. Bottom of Keyslot to Opposite Side of Shaft—H

These figures are obtained by subtracting the versed sine, "G" and the depth of the keyslot "B", from the shaft diameter "F".

4. Top of Key to Opposite Side of Shaft

These figures are obtained by adding to the dimension, "H", the height of the key "C", these figures being as follows:

Key Diameter	Key Height Min.	Key Height Max.
½	.198	.203
5/8	.245	.250
¾	.308	.313
7/8	.370	.375
1	.433	.438
1 1/8	.479	.484
1 1/4	.542	.547
1 3/8	.589	.594
1 1/2	.636	.641

5. Bottom of Keyway to Opposite Side of Bore

These figures are obtained by first subtracting the versed sine, "G", from the shaft diameter, "F", and then adding to this figure the depth of the Keyway "E".

Felt

For the last 18 months a Subdivision under the chairmanship of H. R. Wolf, of the General Motors Corp. Research Laboratories, has been studying and formulating a revision of the present S.A.E. Specifications on Felt. It has been found that these specifications are of considerable value in the purchase of felt and that, while in their present form they are essentially correct, some revisions are necessary.

It will be noted from the revised specifications that two grades of felt have been eliminated as not being used by the automotive industry and three additional grades inserted to provide a proper series of grades for all sizes.

The specifications as submitted to the Parts and Fittings Division are the result of collaboration on the part of the felt manufacturers and the users and have their approval. The Division approved the accompanying specifications as a proposed S.A.E. Standard to be submitted to the Standards Committee for approval.

FELT SPECIFICATIONS

(Proposed S.A.E. Standard)

Felt is manufactured by matting or felting animal and vegetable fibers. Wool, on account of the minute overlapping surface-scales and crimped or crinkled condition, which gives it elasticity, is used without

TABLE 1

S.A.E. Specification No.	Trade Classification	Fiber — Wool, Per Cent	Fiber — Cotton, Per Cent	Ash, Per Cent Maximum	Color	Thickness Tolerance, Plus or Minus, Per Cent
F1	Back Check	100	None	0.75	White	10
F2	Back Check	100	None	1.00	Any Color[2]	10
F3	Back Check	95-100	0.5	1.25	Gray	10
F6	Extra Firm Pad	100	None	0.75	Gray	10
F7	Extra Firm Pad	85-95	5-15	1.00	Gray	10
F10	Firm Pad	100	None	0.75	White	10
F11	Firm Pad	100	None	1.25	Gray	10
F12	Firm Pad	90-95	5-10	1.25	Gray	10
F13	Firm Pad	80-85	15-20	1.25	Gray	10
F15	Firm Pad	60-65	35-40	1.50	Gray	10
F26	Soft Pad	50-55	45-50	1.50	Gray	10
F50	Colored Shoe Upper	100	None	0.75	All Color[2]	10
F60	Asbestos[1]	50[3]		5.00	Gray	15

[1] This is a trade term and does not refer to mineral asbestos.
[2] Except gray and black.
[3] Fifty per cent reworked wool and 50 per cent wool substitutes.

TABLE 2

S.A.E. Specification No.	Weight of Felt, Lb. per Sq. Yd. — Thickness — 1/8	3/16	1/4	5/16	3/8	1/2	3/4	1	Weight, Tolerance, Plus or Minus, Oz.
F1	2.00	3.00	4.00	5.00	6.00	8.00			5
F2	2.00	3.00	4.00	5.00	6.00	8.00			5
F3	1.95	2.92	3.90	4.87	5.85	7.80			7.5
F6	1.75	2.37	3.12	3.87	4.62	6.12			5.0
F7	1.75	2.37	3.12	3.87	4.62	6.12			7.5
F10	1.50	1.75	2.25	2.75	3.25	4.25			5
F11	1.50	1.75	2.25	2.75	3.25	4.25			7.5
F12	1.50	1.75	2.25	2.75	3.25	4.25			7.5
F13	1.50	1.75	2.25	2.75	3.25	4.25			7.5
F15	1.50	1.75	2.25	2.75	3.25	4.25			7.5
F26	1.10	1.50	1.90						10.0
F50			See Table 2-a						5.0
F60			1.50		2.25	3.00	4.50	6.00	10,0

admixture with other fibers in the highest grades of felt. Varying amounts of cotton may be introduced in the lower-grade felts. Hair, on account of its non-felting properties, is not used in the better grades of automotive felts.

The identification of the type and source of the wool fiber is extremely difficult. The best grades of wool fiber are white. Inferior grades are often yellowish and even brown or black in color. The color of the felt is, therefore, in a general way, a check on the quality of the wool used. The white felts are generally made from high-grade new materials. The clear colors produced by dyeing may contain a small amount of clean reworked material, while the grays and blacks generally contain a larger amount of reworked wool. A microscopic examination may be used as a further check on the quality of the wool.

Raw wool contains "wool-fat" and "wool perspiration" in addition to the mechanically adhering impurities or dirt. These materials are largely removed in the scouring process. In high-grade products the presence of these impurities, together with added sizing material, may be determined from the ether, alcohol and water extract. S.A.E. F1, F2, F6 and F10 shall not exceed: Ether extract, 2.5 per cent; alcohol extract, 0.5 per cent; water extract, 2.5 per cent. The lower-grade and darker felts may exceed these values, especially when sizing materials are specified.

Table 1 gives the per cent of wool and cotton fiber, ash, color and thickness tolerance for the commercial grades of felt used in automotive work.

The hardness of felt is controlled by the weight per unit area. Table 2 gives the weight per square yard on the commercial thickness and the weight tolerance. Other thicknesses having the same relative weights are available on special order.

All weights shall be based on the thickness of the felt as ordered and no correction in weight shall be made for variations in the thickness of the material received.

In order to facilitate inspection, the purchaser may, on cut washers and similar parts, convert the weights given in Table 2 and specify the weight per 100 pieces.

Felt used for ball and roller-bearing oil-retainer washers shall be sheared on both sides to give a smooth finish free from "surface fuzz" or "flock."

The quality, appearance and oil-absorption characteristics may be specified to be in accord with the samples approved by the purchaser.

The wool content may be determined by the following method:

Boil a 2-gram sample in from 60 to 80 cc. of a sodium-hydroxide solution (specific gravity 1.02) under a reflux condenser for 15 min. Wash the residue with distilled water until the sodium-hydroxide solution and saponified wool are removed. Press out the water, dry and weigh.

$$\text{Per cent wool} = 100\,\frac{W - 1.05\,w}{W}$$

Where

W = weight of original sample
w = weight of residue

Since hair and other animal fibers similar to wool are saponified and included with the wool, a microscopic examination should be made on the original sample.

General Information.—Back-check, extra-firm-pad and firm-pad felts are recommended for use in washers, bushings, oiling wicks, door bumpers and similar parts. Back check is recommended where light or medium oil is used; an extra firm pad or pad where heavy oil or grease is used.

Soft-pad felt is intended for chassis strips and similar parts.

Colored shoe upper felt is intended for use for ball and roller-bearing oil-retainer washers and for use where an accurate, thin, smooth, high-grade felt is desired.

Asbestos felt is intended for such applications as soft top-padding or cushions.

TABLE 2-A

Specification F50

Thickness, In.	Weight per Yd., 60 In. Wide, Oz.
0.050	20
0.055	22
0.060	24
0.065	26
0.070	28
0.075	30
0.080	32
0.085	34

Annular Bearings, Wide Type

Ball and Roller Bearings Division Recommends Bearings Suitable for Electric Motors

IN APRIL, 1927, negotiations were begun between electric-motor manufacturers and antifriction-bearing manufacturers for the purpose of establishing standard bearing sizes of the extra-wide or so-called double-row type that would be suitable for use in electric-power motors. In June of that year a joint meeting of bearing and motor manufacturers was held in the offices of the National Electrical Manufacturers' Association in New York at which thorough discussion of the project resulted in the Society being requested to undertake a standardization program by the Ball and Roller Bearings Division of the Standards Committee. The subject was assigned to the Division by the Council of the Society as a special project and information was requested from the motor and bearing manufacturers on the basis of which the work was started.

It appeared that different series of bearing dimensions might be necessary

(*Concluded on p.* 666)

Transportation Engineering

Fleet-Maintenance Fundamentals

Superintendency of Motor-Vehicles Is an Exacting Task, Says Leonard Rose

BROAD aspects of the qualifications that the superintendent of a motor-vehicle fleet must have were stated by Leonard Rose, assistant superintendent of the motorcoach department of the Cleveland Railway Co., in a paper he delivered at a meeting of the Cleveland Section. In his opinion the maintenance superintendent confronted with the task of building an organization to care for a fleet of motor-vehicles, be it one composed of passenger-cars, motor-trucks, motorcoaches, taxicabs, or a mixed fleet comprising several types, must remember that the fundamental problems for each type of fleet remain the same and that, for successful operation, it remains only to keep them foremost. Good maintenance will keep the rolling stock in the best operating condition for the least expense consistent with sound economics, and it is essential that the maintenance executive, to build a good organization, must be thoroughly conversant with various factors not mechanical but of equal, if not greater, importance, as well as that he have a thorough knowledge of the mechanical details. These factors are:

(1) The policy of the operating company
(2) A comprehensive and detailed knowledge of the kind of service the rolling-stock will be expected to render
(3) The type of equipment available on the property or in the market
(4) The economics of good maintenance
(5) In what average standard of repair the equipment should be kept
(6) The type of personnel necessary and available, together with an educational program for the mutual benefit of employe and employer
(7) The control of results by conversion of pertinent statistics into standards of comparison for the purpose of diagnosing competition, and how this can best be done.

Continuing, Mr. Rose said that the policy defines the undertaking as well as the ideals of the founders, setting forth the methods to be used. The degree to which an undertaking will succeed depends entirely upon the soundness of the policy and the intelligent and sincere efforts put forth by the entire organization to further the ideals for which it stands. A maintenance program therefore must in no way conflict with the policy.

The management should provide sufficient spare equipment so that reasonable repairs can be made. Having done this, it has a right to expect uninterrupted service from the equipment, and the maintenance man's responsibility is to see that this expectation is realized to the fullest extent for the minimum cost. This can be accomplished only by the use of a plan in which the prime motive is to make adjustments or replacements of units immediately prior to failure. Fitting such a program into the transportation plan, as a whole, requires a knowledge not only of the kind of service the rolling-stock is expected to render, such as loads, routes, speed, and average miles operated per given period of time, but also of the natural length of life built into the various units which make up the vehicle. The last can be acquired only by a careful study of a mass of detailed data which must be gathered and compiled from actual operation. The good maintenance-man will be guided only by such data and not by impressions, which usually are misleading.

Maintenance problems, while fundamentally the same, differ in detail, according to the class of work expected from the vehicles. For example, we have the passenger-car used for demonstration purposes only; individually owned passenger-cars used for the owner's personal transportation needs; the taxicab, rendering transportation for revenue; motor-trucks for freight transportation; and motorcoaches for the mass transportation of passengers. The owner's maintenance requirements in each case will differ in every respect but one; that is, continuity of service.

Motorcoach Maintenance

The motorcoach presents most, and in many cases all, of the problems of all other classes of automotive maintenance, and to an even greater degree. Being in competition with the privately owned automobiles and taxicabs, it must provide comfort, safety, speed, capacity, dependability, quietness and cleanliness. City, fast-interurban, and city de-luxe express are the three major classes of motorcoach service. It is necessary not only to provide safe operation, but also to guard against accidents to persons and wearing apparel. The windows must be washed each day, the seats cleaned and the floors swept or washed; this is a considerable task.

The satisfaction which can be derived from a transportation service and the extent of the maintenance problem depend largely on the vehicle used and how wisely it was chosen. The responsibility of the maintenance man here is to analyze his equipment from the viewpoint of its adaptability to the transportation problem as a whole. The sources of information for this study should be the records of performance of vehicles already in the service and those of the same type of vehicle in similar service elsewhere; a knowledge of types of equipment that are available in the market; the records of performance of these types in service comparable with the one in question; and a knowledge of general practice as a result of experience, as acquired from trade journals and by an exchange of ideas with others in the same or allied fields of endeavor. The superintendent is then in a position to replace certain units, change the design of others, and make changes in repair methods or maintenance routine.

For example, the brakes on our first 30 double-deck coaches proved to be inadequate, and it was necessary to reline the brakes each 3500 miles, representing at that time slightly more than a month's service. It was found advisable to redesign the entire brake-shoe rigging, which resulted in better braking and a lining life of 8000 miles. Subsequent experimentation proved it possible to increase the lining life to 20,000 miles. The brake-equipment company then designed an entirely new brake, incorporated features facilitating inspection, ease of adjustment and relining the shoes without removing them from the axle, and made provisions to increase the lining thickness as well as the area, thus assuring a minimum lining-life of 30,000 miles, which I believe will be increased to 50,000 miles. Further, to use our old worn brake-drums with these new brakes, we turned them to a standard oversize, shrinking them over a gun-iron ring cast for us by a local foundry. The resultant saving in maintenance labor will more than pay for the cost throughout the life of the coach. The brake-drum we have devel-

oped combines the advantages of the original long-life drum and the throw-away type of drum, without the disadvantages. The lining-life of our single-deck coaches is rapidly being increased from approximately 12,000 miles to 30,000 miles without changing the lining dimensions, and we have 125 pieces of equipment for which, barring accidents, we shall never have to buy brake-drums.

Replacements of Units and Parts

The economics of good maintenance should dictate to what extent replacements should be made of entire units or of their integral parts, as well as what shop equipment and how much building space are to be provided. No capital expenditure is justified unless a return is assured either in the form of new capital or of a saving to be effected by such an expenditure. However, any planning that does not take expansion into consideration is not economically sound even though it is productive of efficient operation at the time it is inaugurated. It must also be remembered that some of the repair work can be done more economically by the manufacturers of the individual units or by specialty service-stations, even though the charge for labor be more than that of the fleet's maintenance organization. Here, the volume of similar repair work is the chief controlling factor.

The extent to which equipment with which to make repairs should be installed is worthy of thorough investigation by the maintenance executive. The "average" condition of repair in which the vehicles are kept must be reasonable; hence, a standard should be set that is in keeping with the service to be rendered and within the limitations of the vehicle itself. Maintaining equipment in a reasonably high average standard of repair is far more economical than keeping it at a low average. I am firmly convinced that the pay-as-you-go policy is the least expensive.

Personnel Practices

The problem of personnel is the most important one confronting an executive. The qualifications of the individuals should be matched with the requirements for the job. The workers must be reasonably happy in their work and have some incentive in the way of advancement so that they will continue to do good work and broaden their viewpoints. Means for preventing stagnation should be sought continuously. All positions that become vacant should be filled by promotion wherever possible. Educational programs in the form of meetings and letters or bulletins should be carried out.

Our motorcoach department holds a series of foremen's meetings. A weekly meeting is attended only by the day foremen, who are held responsible for the successful operation of their respective garages. A monthly meeting is attended by both day and night foremen, inspectors and our engineer. In addition, monthly meetings are held by the transportation men and the stock men. In order that the key men in the maintenance and in the transportation departments may have a better conception of each other's problems a combined transportation and maintenance meeting is held every other month.

We have found these meetings to be very efficacious, particularly in eliminating misunderstandings which are the chief cause of dissension. The information gathered at the meetings is carried on to the men by those who attended the meeting and also in the form of letters which we choose to call "technical information sheets," which deal with standard procedure and adjustments and are continually being revised. These are numbered consecutively, a copy is sent to each man, and a complete file is kept in each foreman's office. Statistics in the form of charts which tend to show the trend in the operation are discussed at the meetings, and some of these data are also posted on bulletin boards. These means all serve to teach each employe what his particular responsibilities are and encourage him to be willing to accept them.

It will be to the maintenance man's advantage to be thoroughly familiar with the many sources of labor supply. New employes should be chosen insofar as possible from the viewpoint of their potential executive ability. Promises should not be loosely made to employes. A new employe should be given a good insight of the ideals of his employer and what will be expected from him. He should be made to understand that his progress depends entirely on how well he applies himself to his work, what his opportunities are, and what he has done to fit himself for a better position. He must be made to feel that he can discuss his problems freely with his superiors.

There is a real scarcity of well-trained intelligent maintenance-men. The sooner each of us accepts this fact and does everything in his power to develop real maintenance-men, instead of hiring and firing as may suit his various moods or fancies, the sooner this important industry of automotive maintenance will take its rightful place in the business of transportation.

Control of Results

Control of results can best be accomplished through the medium of friendly competition. The employe's pride in the organization and in his work should be stimulated so that he will enter the competition with the right spirit. No greater satisfaction exists than that of knowing that one's efforts have favorably affected the results obtained, unless it be the privilege of watching the progress of these efforts toward attainment of the ultimate goal. Therefore, some fair standards for measuring the results should be devised. These standards must be in such units that, when applied to the efforts of various groups in the contest, the results obtained will be comparable. They should be set up or placed in chart form so that they will indicate the trend or progress being made. Some of the units used by our maintenance department are: per motorcoach, per motorcoach mile, per day, per month, and so on. These are set up in the form of graphs or line charts which usually cover a one-year period and indicate the trend. These charts not only form a ready means for comparing the results obtained each month with those of the preceding months of the current year but with those of the preceding years as well. They constitute a splendid means for guiding the efforts of the workers.

Preventive Maintenance

Successful fleet-operation calls for a system that is based on the principle of preventive maintenance. The major activities of the organization must consist in making predetermined repairs at regularly scheduled periods. We call this "scheduled" maintenance. It consists of a group of different types of inspection made at various intervals based on the mileage operated. If the inspection and overhaul schedule has been well designed, the operation of the vehicle will be practically free from failures between these inspections and the efficiency of the work done is indicated by the schedule. Failures may be due to a faulty schedule, weak design, poor workmanship on our part, or the use of defective parts. When the cause has been determined, the person or persons responsible are notified.

We make every effort possible to record in a permanent form all important work done to any coach. I believe that the responsibility for development in design is not only the manufacturer's but the operator's. The operator must furnish to the engineer detailed data of performance of the vehicle in actual operation and not impressions of the various mechanics in his shops.

Motor-Vehicle Application

FACTORS involved in motor-vehicle application to business in general, to the work of the commercial organizations, the commercial operators and the railroads, are dealt with in the paper by W. F. Banks which begins on p. 621. The use of cost data that enable the buyer and the seller to be brought to the mutual understanding necessary to establish the economic value of motor-vehicle application is also discussed.

Army Transport Pageant

Demonstration and Exposition of Military Automotive Vehicles at Camp Holabird, June 12 to 14

THE MILITARY Transportation Pageant and Exposition to be held June 12, 13, and 14, at the Holabird Quartermaster Depot near Baltimore will consist of a daily pageant depicting the rise of transportation through the ages and portraying types the National defense necessarily resorted to during the conflicts notable in the history of the United States.

Following this there will be demonstrations of the performance ability or prowess of the Army-produced special vehicles; transportation that by nature of its complicated design has not been produced in commercial manufacture.

A test demonstrating course is to be prepared whereby certain features of design shall prove particularly prominent. This will include marsh ground, sand terrain, obstructions and hazards difficult of negotiation. Included in this demonstration will be vehicles of the four-wheel-drive type in all capacities; artillery tractor-trucks, wheeled type, driven by six pairs of dual wheels and tires; vehicles for artillery tractor and ammunition hauling, equipped with front-wheel drive and endless-rubber-belted rear drive; low-slung six-wheel trucks designed for combat-tank transportation, whereby it is possible for the tank to load itself over the tailgate; gas-electric powered and power-unit trucks; mobile powerplants for field lighting in areas remote from electric current supply; and trucks embodying all forms of four-wheel rear-drive bogies for use in the design of the six-wheel vehicle. There will be vehicles equipped with every form of brake systems, as complicated as the six-wheel hydraulic brake on a six-ton chassis; and the possibilities of the radial engine in truck practice and of multi-wheel drives will be demonstrated.

In addition to the pageant and testing demonstrations, there will be a commercial exhibition of chassis, accessories and maintenance machinery covering in excess of 50,000 sq. ft. of floor space. Passenger-car transportation will not be included in the exhibition.

Training and Maintenance Systems

For the particular benefit of those whose field of endeavor lies in the operation of transportation, the Motor Transport Training School for officers and enlisted men, maintained by the Quartermaster Corps in connection with this post, will be open in all its phases to the assemblage. The nine-months' concentrated course of training will be clearly defined in detail. This course terminates in a 1500-mile overland convoy of heavy transportation.

The unit-replacement system of vehicle maintenance will be graphically demonstrated for the benefit of those responsible for vehicles maintenance. The Government shops and warehousing system will be open to those interested. Methods of training, caring for and discipling the soldier also will be open to inspection.

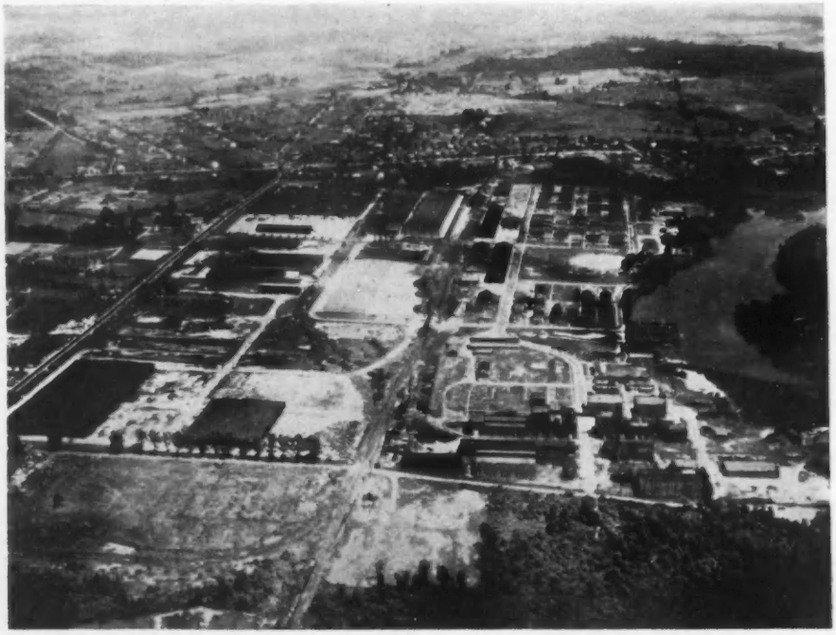
An engineer will be available throughout the entire period who will be provided with designs, constructional details, costs and test data covering each Government-produced vehicle in the exposition. Able instructors also will be present to reply to any questions.

Interests That Will Be Represented

Those attending the pageant will include transportation men of the National Defense Forces, the Navy, Marine Corps and the Army; the Government bureaus, Post Office, Veterans, Department of Agriculture and Commerce; the National Guard and Officers Reserve Corps; foreign dignitaries, their military attachés and purchasing representatives; the State highway commissions with their engineers; representatives of the steam and electric railroads; sales and engineering representatives of the manufacturers; trade associations; and fleet operators. Attendance will be through cards of invitation to the commercial automotive world through the cooperation of technical and trade associations. No admission charge will be made of those attending the pageant who are connected with the activities of the Government, the automotive industry, or any of its closely allied branches.

The Holabird Depot is but six miles from the best hotels in Baltimore. The Hotel Emerson, one of the leading hotels of the city, has extended special rates to those visiting the exposition, and desired reservations, if included with requests sent to the Holabird Quartermaster Depot for attendance invitations, will be promptly attended to.

The Society has a limited supply of attendance cards available, or they may be obtained in any desired number directly from the Commercial Affiliations Committee, Holabird Quartermaster Depot, Baltimore, Md.



AIRPLANE VIEW OF QUARTERMASTER'S DEPOT AT CAMP HOLABIRD, SELECTED FOR THE MILITARY TRANSPORTATION PAGEANT AND EXPOSITION

Aeronautic Engineering

History Made at Conference

Aeronautic Research Problems Presented at N. A. C. A. Meeting—Autogyro and Diesel-Engine Airplane Demonstrated

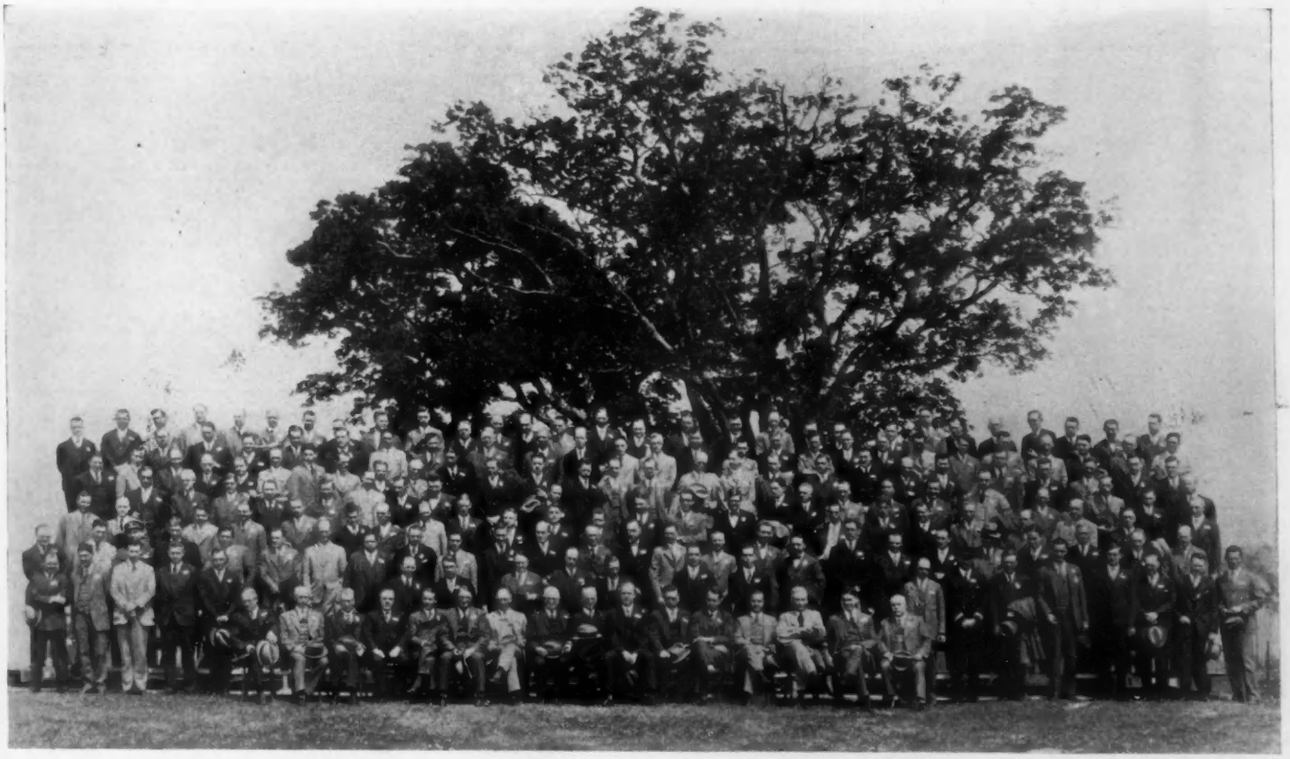
THE INTRICACIES of aeronautic research and the vast organization and equipment necessary to carry on such research were ably exhibited to 200 of the foremost engineers in the aeronautic industry at the Fourth Annual Engineering Conference of the National Advisory Committee for Aeronautics at Langley Field, Va., May 14.

While most of the delegates made the trip by boat from Washington, a large number, as should be expected, flew to the conference. The flying branches of the Government were well represented by the Assistant Secretaries for Aeronautics of the Army, Navy and Commerce and the heads of departments of the different Air Corps.

The delegates were welcomed at the morning session of the Conference by Dr. J. S. Ames, the Chairman. Elton W. Miller, chief of the Aerodynamics Division of the Committee, then described the work accomplished by his division during the last year, the work in progress at present, and some of the contemplated projects. Results of some of the research were amply illustrated by means of charts which presented an analysis of the investigations conducted last year on the distribution of aerodynamic loads on wing surfaces, tail surfaces and fuselage; the effect of mass distribution on flat spins; landing-gear investigation, comparing the oleo with the rubber-core type; water-pressure distribution on float bottoms; and drag tests on spheres.

Drag and Safety Data Given

In addition, data were presented on the study of cowling and cooling problems in connection with the use of radial air-cooled engines on multi-engined planes, with particular relation to the wing or the wing cellule. Fur-



DELEGATES TO THE FOURTH ANNUAL AERONAUTIC ENGINEERING RESEARCH CONFERENCE AT LANGLEY FIELD, VA., ONE-THIRD OF WHOM ARE MEMBERS OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Seated in the Front Row, Left to Right, Are the Following, Those Indicated by an Asterisk Being Members of the National Advisory Committee for Aeronautics: Dr. George W. Lewis, Director of Aeronautical Research; *Dr. Orville Wright; *Dr. D. W. Taylor, Vice-Chairman; *Dr. Charles F. Marvin; *Capt. E. S. Land, U.S.N.; *Brigadier-Gen. W. E. Gillmore, U.S.A.; *Major-Gen. James E. Fechet, U.S.A.; *Dr. Joseph S. Ames, Chairman; *Rear Admiral William A. Moffatt, U.S.N.; *Assistant Secretary of Commerce, William P. McCracken; the Hon. W. H. Newton, Secretary to the President; the *Hon. Edward P. Warner; *Harry F. Guggenheim; Senator Hiram Bingham; Assistant Secretary of the Navy, David S. Ingalls; *Dr. George K. Burgess

ther investigation will be conducted in connection with the nacelle drag and interference on tri-motored aircraft, and the program of the Committee provides for considerable new research on wing and nacelle tests.

Results of the study on characteristics of an airfoil section as affected by slots, boundary-layer control and warped surfaces to improve the safety factor in aircraft by improving the lift and non-spinning characteristics also were presented.

A study is being made of propeller characteristics with a view to determining the loss of propeller efficiency at high tip-speed. This embodies research on propeller interference and high-speed propellers.

The chief of the Powerplant Division presented the results of the study of supercharged aircraft engines and heavy-oil injection engines. This included data on the flight performance of the DH-4 airplane with an engine equipped in turn with no supercharger, the Roots-type supercharger and the turbo-type supercharger. The oil-engine investigation involved studies of time lag of injection, by the photographic method; the effect of air turbulence on spray penetration; cylinder-pressure modifications for oil; and the effects of engine load and engine speed on performance.

Following the morning conference, the delegates were conducted through the various laboratory buildings where many of the tests previously outlined were demonstrated. These demonstrations were made in the variable-density wind-tunnel, the powerplant laboratory and in the large wind-tunnel where a very comprehensive demonstration was given of the experiments on propeller efficiencies at high tip-speed.

The afternoon conference was in the nature of an open forum at which various engineers in the industry presented suggestions as to the subjects for future research which in their opinion should be undertaken by the N. A. C. A. This part of the Conference probably will go down in history as marking the setting of two new milestones in aeronautic progress: the first Autogyro cross-country flight in America and the first public demonstration of the Diesel aircraft-engine. Tremendous interest was taken in the

SOME OF THE PERSONAGES PROMINENT IN AERONAUTICS GATHERED AT THE N.A.C.A. CONFERENCE

(1) A. V. D. Willgoos, Chief Engineer, Pratt & Whitney Aircraft Co.

(2) Left to Right—Hon. D. S. Ingalls, Assistant Secretary of the Navy for Aeronautics; Brigadier-General Fechet; Senator Hiram Bingham, of Connecticut; Admiral Moffatt, Chief of the Bureau of Aeronautics, Navy Department; Hon. William P. McCracken, Assistant Secretary of Commerce for Aeronautics; and Harry Guggenheim

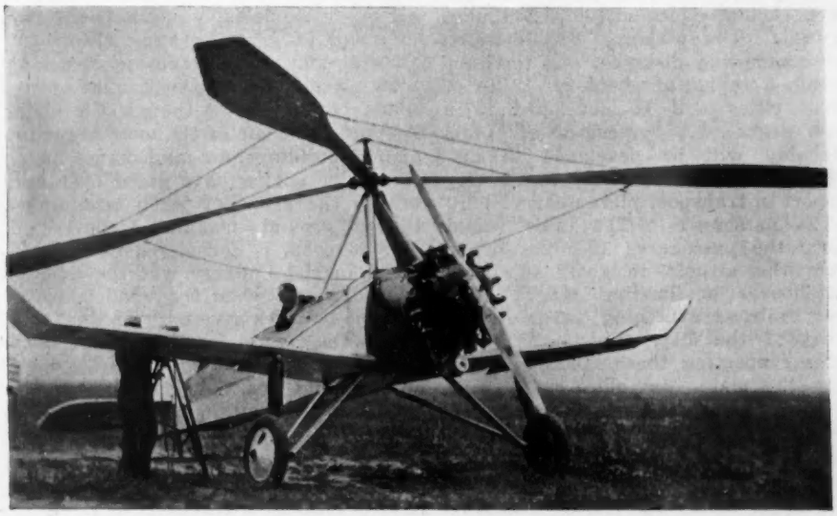
(3) Brigadier-General Fechet and Admiral Moffatt

(4) Charles L. Lawrence, President, Wright Aeronautical Corp.

(5) Left to Right—Orville Wright, Grover Loening and Dr. H. C. Dickinson

(6) F. G. Coburn, of the Aviation Corp.; and Capt. E. S. Land, of the Guggenheim Foundation for the Promotion of Aeronautics

flights and performance of the Pitcairn Autogyro, flown by H. F. Pitcairn, to show the remarkable control and landing possibilities of this type of aircraft. While the plane exhibited was one of the types built abroad by Cierva, the inventor, it incorporated some improvements such as dihedral wing-tips and the tail fin, which have been added by the Pitcairn company here. Mr. Pitcairn asserted that the new Autogyros now being built at the Pitcairn plants will incorporate many additional improvements that will add to their efficiency and improve their performance.



PITCAIRN-CIERVA AUTOGYRO FLOWN FROM PHILADELPHIA TO LANGLEY FIELD, VA., FOR DEMONSTRATION

No less spectacular was the demonstration of the Packard Diesel engine shown publicly for the first time by Capt. L. M. Woolson, its designer, and Walter Lees, the pilot of the Stinson airplane in which the engine is mounted and which was flown from Detroit to Langley Field for the Conference. The quick starting of the engine was and still is the subject of much discussion among those who witnessed the remarkable performance.

It is worthy of note that more than one-third of the delegates at this distinguished gathering are members of the Society. Captain Woolson is Chairman of the Aeronautic Division of the Detroit Section and a large number of those present are active or interested in the work of the Society as officers or members of various committees.

The National Advisory Committee for Aeronautics is to be complimented on the smoothness and efficiency with which the Conference was conducted. The events scheduled took place at the times specified and the convenience and comfort of the delegates were at all times paramount.

Airport Requirements Considered

Pennsylvania Section Closes Season with a Meeting on a Subject Agitating Philadelphia

WITH the cooperation of the Aeronautic Club of Pennsylvania and the Aircrafters, the Pennsylvania Section of the Society brought its 1929 season to a close with a flourish on May 8. The event was an aeronautic meeting and the subject was airports, a question that is engaging the attention of the aeronautic interests of Philadelphia and a large part of the rest of the State, who are urging upon the City Fathers the establishment of a suitable municipal airport in Pennsylvania's metropolis.

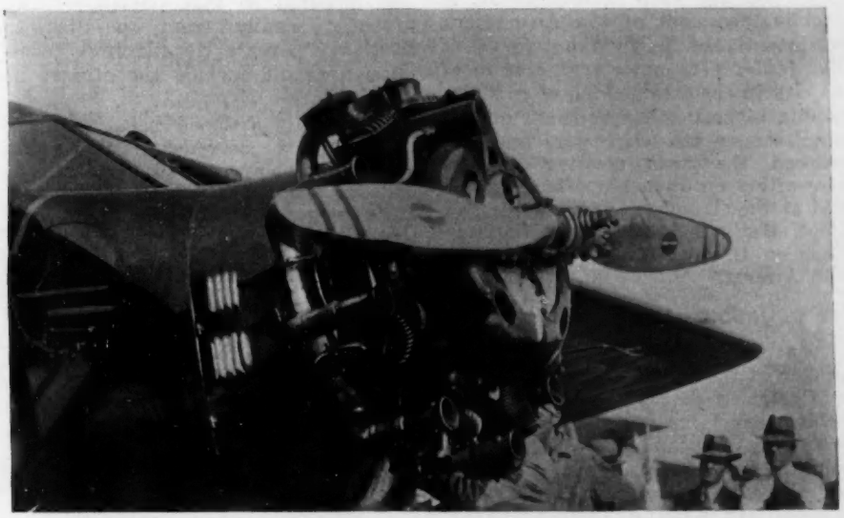
Expectation by the Section officers of an unusually large attendance was justified, as 138 members of the three organizations and their guests were present at the dinner and about a score more came later to attend the technical session. The dinner was held on the roof garden of the Hotel Walton and the meeting in the crystal room of the hotel, as these afforded more ample accommodation than the rooms of the Philadelphia Automotive Trade Association where the meetings of the Section were regularly held during the season. A pleasing feature of the dinner was the musical and professional dancing program provided by the hotel.

Result of Section Election

Chairman Adolph Gelpke started the technical session by reminding the members of the Section of the golf meeting arranged for May 17 at the Tedyffrin Country Club and mention of the Summer Meeting of the Society, for which a surprise Pennsylvania Section stunt has been arranged through the efforts of Cap. Risley. A report by the tellers of the votes for Section officers for next year showed the election of the following:

Chairman, Dalton Risley, Jr.
Vice-Chairman, O. M. Thornton
Treasurer, Henry B. Coleman
Secretary, E. B. Neil

The new officers were congratulated



PACKARD DIESEL ENGINE INSTALLED IN STINSON PLANE WHICH FLEW FROM DETROIT TO LANGLEY FIELD

by the Chairman and the retiring officers were thanked for their earnest efforts in making the 1929 season so successful. Mr. Gelpke then relinquished the chair to W. Lawrence LePage, of Pitcairn Aviation, who had arranged the program, secured the speakers and taken care of all the other arrangements for the meeting. After reading a telegram from the Mayor of Atlantic City expressing regret that an important conference prevented his acceptance of an invitation to attend the dinner and meeting, Mr. LePage turned the meeting over to Lawrence Saunders, president of the Aero Club of Pennsylvania for a brief business meeting of that organization.

Aero Club and Aircrafters Interested

Mr. Saunders stated that the Club appreciated the invitation to join in the occasion, as the members, who are representatives of 35 aeronautic interests in and around Philadelphia, feel that their most important present activity is in helping to secure adequate airport facilities for the city. At the invitation of the Club the Department of Commerce had sent a man to investigate the situation and make recommendations. As a result, the report recommended Hog Island as the site for a municipal airport. Proposed amendments to the constitution of the Club, to provide for increasing the present membership from 200 to 300 so as to make greater activity possible, were read and their adoption moved and seconded.

Mr. LePage then introduced H. S. Cocklin, president of the Aircrafters, who mentioned briefly the interest of that junior aeronautic organization of the city in the establishing of a Philadelphia airport of appropriate extent, completeness and character, and announced the next meeting of the Aircrafters on June 13. This is to be held at the Chamber of Commerce and Lieut. Herbert Brod, U. S. N., is to speak on Uses of Radio in Connection with Aircraft.

Keally Outlines Airport Requirements

Francis Keally, the first scheduled speaker of the evening, was introduced by Chairman LePage as a terminal architect and engineer, a member of the faculty of Columbia University, and technical advisor in the Lehigh Portland Cement Co.'s airport-design competition. Mr. Keally presented a paper on The Architectural Treatment of the Modern Airport. He urged the great importance, when planning an airport, of having the vision to anticipate aviation developments of the future so as to avoid as far as possible mistakes that have been made by the railroads in building their great terminals and such a mistake as was made in building the airport at Croydon, England. The original buildings at Croydon, erected at a cost of $600,000, soon became obsolete and last year were razed and replaced by more adequate structures at a cost of $1,000,000.

Since Colonel Lindbergh made his epochal Atlantic flight, $300,000,000 has been spent on airports by 1000 communities in this Country, said Mr. Keally, and it is reasonable to suppose that an additional $200,000,000 will be spent by 1000 more communities in the next 12 months. Airports for business men must be close to the great centers of population, while suburban airports should be located 100 to 200 miles distant. The airplane will increase the commuting distance, and territory within a radius of about 200 miles of great cities will be developed to a high degree. A system of air taxis probably will be developed to distribute passengers arriving at the city airport in transport planes carrying 10 to 25 passengers. The taxis would carry the passengers 10 miles or so from the airport to roofs of large warehouses or landing stages built over railroad switching yards in the heart of the city. Pneumatic mail-tubes connecting these landing stages with the main post office will result in the speedier delivery of air mail. Ample facilities should also provide for the prompt handling of express and small-freight shipments by air.

It is of most importance that airports be built so as to provide for a future expansion of not less than 100 per cent. At large cities as many airlines as possible should converge at one terminal so that passengers can transfer readily from one line to another. Every city-planning commission should include the airport in its plans.

Mr. Keally visioned beautified airports with not only every facility for handling airplanes, mail and express and for the convenience and comfort of passengers, but also with provision for recreation and entertainment for visitors. He believes the airport can be made a real civic center and that it will become so important that an entire community will develop around it. To stimulate the designing of such airports, the Lehigh Portland Cement Co. is sponsoring a design competition for a first prize of $5,000, three other prizes and awards for ten honorable mentions aggregating another $5,000. This competition closes Nov. 18, 1929.

Johnson Gives an Aviator's Views

Following Mr. Keally, an amusing and practical talk was given by A. E. Johnson, of the Johnson Airplane & Supply Co., of Dayton, Ohio, who established his own supply business and flying-field at Dayton in 1920 after five years' experience as a pilot in the Air Service and instructor in the Signal Corps. He had just made a tour of the Southwest and said that after looking over airports in all parts of the Country he found them in a deplorable condition as regards ground and accommodation facilities. Many that have a good deal of business have nothing in the nature of waiting-rooms or restaurants where real meals are served. At almost every airport the ground either is soft and muddy in wet weather or very dusty in dry weather. The propellers create small tornadoes that "throw half of the real estate into the hangars and engines." The remedy is to have hard surfaces all over the fields, with the exception of strips of grass perhaps 200 or 300 ft. wide and several thousand feet long where a pilot having no brakes on his plane can land. Although Cleveland Airport has some of the most beautiful airport buildings, air-mail planes many times this spring have nosed over and broken the propeller when landing on the soft ground. Oakland Airport, said Mr. Johnson, is considered one of the finest in the Country, yet the field is bone dry and when the wind is blowing one becomes covered with dust and dirt. The reason for the lack of hard fields has been the absence of brakes on airplanes and the dependence upon tail-skids to stop them.

Large airports were advocated by the speaker, who also emphasized the importance of making visitors welcome and providing attractions for them. He is not optimistic regarding solution of the problem of safe landing in blind flying; he does not think passengers are going to wear parachutes very soon or will want to obey a pilot's orders if he says, "Come on, fellows; let's all go."

Air-Traffic Congestion a Problem

One of the major problems at commercial airports is the air traffic; that at Chicago has increased 400 per cent over last year and probably will increase much more in the next year. Even now an airplane sometimes must wait 20 min. before it gets a signal to take off or to land. Airport managers should get together with representatives of the Department of Commerce to agree upon traffic rules and regulations that will eliminate such delays. Mr. Johnson's company has suggested to the Department that each landing-field be bisected by an imaginary line parallel to the direction in which the wind is blowing and that incoming planes land to the right of the line and departing planes take off on the left of it.

In conclusion, Mr. Johnson expressed much doubt regarding airplanes landing on the roofs of buildings in the near future; he wants the epitaph on his tombstone to read, "Here lies the oldest pilot but not the best." He said he thinks that in 10 or perhaps 20 years we may "all have our individual

buses on our backs; we will press a button, get radio power, and scoot out of the window."

Chairman LePage promptly took exception to the concluding remarks and said he would take Mr. Johnson out to Pitcairn Field the next day and try to prove that it will not be very difficult to land on top of a good-sized roof.

Much interesting discussion followed, participated in by N. G. Shidle, of the Chilton Class Journal Co.; Albert R. Jacobs, of Fischer & Jacobs; W. S. Bomler, director of finance of Mercer County, N. J.; Kern Dodge, consulting engineer; C. C. Trump, of the Terminal Engineering Co.; and Messrs. Keally, Johnson, Saunders, LePage and Gelpke.

Mr. Bomler gave a brief description of the new airport at Trenton, where 208 acres were acquired at a cost of $50,000, $15,000 was expended on drainage, and a brick and steel hangar was erected at a cost of $50,000.

Wichita Section Proposed

Southwest Members Vote for Appointment of Committee to Organize a Local Aeronautic Section

THE FIRST step in the organization of a Wichita Section of the Society was taken on May 1 at a luncheon meeting, at the Lassan Hotel, called at the request of Mac Short, chief engineer of the Stearman Aircraft Co. The meeting was attended by 33 engineers and executives connected with aircraft companies in Wichita and cities within a short flying distance, which is indicative of the great interest in organizing a local Section.

A motion to undertake the organization of a Section was passed unanimously, and the chairman was authorized by a unanimous vote to appoint a committee of five members and nonmembers, this committee to include the chairman, to carry on the organization work until the first meeting, which it was agreed should be held in the early autumn. A motion was also passed to request the Council of the Society to recognize the organization efforts of the committee and to finance the organization until it became self-supporting.

Dr. H. W. Foght, of the University of Wichita, stated that the University would be tremendously interested in the organization of the Wichita Section. He felt that it would be an excellent move for everyone interested in aeronautics, pointing out that, if Wichita is to be recognized as the aircraft capital, it should certainly have a Section of the S.A.E. devoted primarily to aeronautic-engineering activities. He felt that the existence of such an organization would result in the aircraft engineers getting together for the discussion of common problems, wiping out misunderstandings and jealousies that would otherwise be almost certain to arise.

Conditions Favor Technical Sessions

The history of the Society in aeronautics, with particular reference to the proposed reorganization along professional activity lines, was reveiwed by Charles Heywood, manager of the Sections Department, who attended the meeting at the request of Chairman Short.

In connection with the size of the proposed Section, Mr. Heywood quoted W. C. Naylor's discussion at the April 10 meeting of the S.A.E. Aeronautic Committee with reference to the difficulty of holding highly technical aeronautical meetings of the Detroit Aeronautic Division, it being impossible to discuss such subjects in meetings at which a large attendance is considered necessary. It was felt that conditions in Wichita would be conducive to the holding of highly technical sessions that would be extremely worthwhile.

Mr. Moehring called attention to the fact that a social organization is absolutely essential to promote contact among men in the same and allied fields of interest.

Those Who Attended the Meeting

Members attending the conference were:

C. A. Braukman, Swallow Airplane Co.
Wilton W. Briney, Butler Aircraft Corp.
E. W. Cessna, Cessna Aircraft Co.
W. R. Clark, Jr., Linde Air Products Co.
W. C. Cumming, Watkins Mfg. Co.
G. Harold Faulkner, Coffman Monoplanes, Inc.
H. W. Foght, School of Aeronautics, University of Wichita
L. H. Height, Mooney Aircraft Corp.
Fred W. Herman, Okay Engine Co.
W. P. Innes, Jr., Stearman Aircraft Co.
Felix W. A. Knoll, Knoll Aircraft Corp.
A. Koerbling, Aeronautics Branch, Department of Commerce
Dan Lake, Swallow Airplane Co.
A. J. Lear, Lear Aircraft Corp.
A. E. Martin, Aircraft Steel Co.
J. I. Michaels, Wichita Blue Streak Motors Co.
Don C. Moehring, consulting engineer
A. W. Mooney, Mooney Aircraft Corp.
Oscar D. Nelson, Butler Aircraft Corp.
C. A. Noll, Wichita Airplane Mfg. Co.
H. Rawdon, Travel Air Mfg. Co.
George Sawallesh, Central Airlines
Mac Short, Stearman Aircraft Co.
Lloyd Stearman, Stearman Aircraft Co.
M. J. Stone, Supreme Propeller Co.
L. H. S. Stratton, Mosbacher Motor Co.
William P. Sullivan, Sullivan Aircraft Corp.
A. L. Swenson, Swenson Motor Co.
D. A. Swenson, Swenson Headlee Engineering Co.
Norman G. Warsinske, Central Airlines Co.
George C. Yunker, Yunker Aircraft Co.
Charles Heywood, Society of Automotive Engineers

Attendance Record Goes to Oakland

Estimated 50,000 Spectators at Northern California's First Air-Race Meet and Dinner

ALL records for meetings of the Society were shattered on April 20, when a crowd estimated by the local police to number 50,000 instead of the smaller number mentioned in the brief report in THE JOURNAL for May, attended the outdoor meeting of the Northern California Section at the big Oakland airport. The afternoon meeting included air races, sanctioned and superintended by the National Aeronautic Association; a dead-stick landing contest, and free rides drawn by 50 of the visitors. In the evening a dinner was given at which 973 guests were seated, 60 of them at the head table. It was served in hangar No. 1 of the Oakland Airport, which was placed at the disposal of the Section by the Western Air Express, and was followed by a speaking program and the awarding of prizes for the contests of the afternoon.

Prizes totaling nearly $2,000 attracted entries of about 30 airplanes for the contests. The races were run over a triangular course of 5.2 miles, marked by one pylon at the starting and finishing point on the landing-field and two-pylons to the southeast, one of them located in San Francisco Bay. Two of the steel pylons, which were 40 ft. in height, were purchased for the occasion out of funds derived from advertising in the program and presented by the Northern California Section to the National Aeronautic Association for future use.

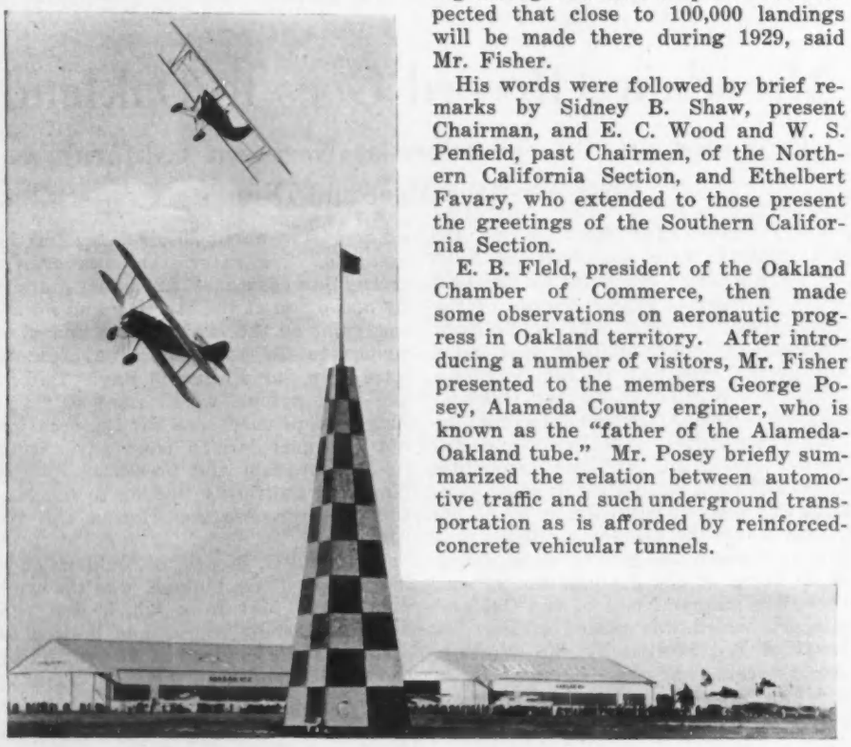
Raymond G. Moore, of Oakland, flying a Travel Air biplane, was the winner of the first race, which was run over a 20.8-mile course and limited to planes having engines of 510 cu. in. or less. His time was 14 min. 37 sec., and he was rewarded by a cash prize of $250 and a trophy. Second place, carrying a prize of $150, was won by Basil Russell, in a Curtiss Robin; and

Norman A. Goddard won the third prize of $75 with his Waco biplane. Prizes for this race were donated by the Shell Oil Co. As there were 10 entries, the race was run in two heats and the award was made on the basis of the fastest time. Bernard M. Foster was the only entrant who failed to finish, as he was forced down without injury by engine trouble.

Thrills but No Accidents

Only two starters appeared for the Associated Speed Special for women, over a course of 15.6 miles, as one of the entrants failed to arrive because of engine trouble. The winner of the trophy and $150 prize was Miss Marvel Crosson, of Los Angeles, sister of Joseph Crosson, aid to Sir George Wilkins on his Arctic flight. Mr. Crosson addressed the crowd through the loudspeakers during the afternoon. The second prize of $100 was won by Miss Maxine Dunlap, a flying stenographer of Oakland, who piloted her plane to a safe landing after losing a tire as she struck the ground. No more serious accident occurred. The prizes for this race were given by the Associated Oil Co.

A Red Crown, named after the donor of the prizes, and $250 in cash were won by Arthur Ayres, of Alameda, in a Stearman airplane, his time being 12 min., 43.2 sec. in the 20.8-mile race limited to 800-cu. in. engines. Second prize of $150 was awarded to Franklin Rose, and Harry Abbott won $75 for third place.



RAYMOND MOORE AND NORMAN GODDARD ROUNDING NO. 1 PYLON IN FIRST RACE

In the dead-stick landing contest, W. D. Wright won $100 for coming to rest within 11 ft. of the mark after shutting off his engine at an altitude of 1000 feet. Bernard Foster was consoled for his earlier mishap by winning $60 for second place in this contest, and D. C. Warren secured the third prize of $40. Fourth, fifth and sixth prizes of merchandise orders were awarded respectively to Kenneth Neese, George McCallum, and Harry Abbott.

The final race was the 26-mile Australian pursuit event, in which any plane that was passed by another was thereby eliminated. Four planes were disqualified in this way before Franklin Rose, in a Stearman airplane, was declared the winner with a time of 14 min. 36 sec. Second place went to W. A. Williams and third place to W. D. Wright. The prizes of $250, $150, and $75 for this, the most spectacular race of the day, were donated by the Richfield Oil Co.

Meeting in 200-ft. Hangar

At the dinner that followed the race meet, Herbert L. Miller, East Bay Vice-Chairman of the Section, voiced the thanks of the Section for the cooperation that had been extended to it so liberally and introduced as toastmaster Ralph Fisher, president of the Oakland Port Commission. After paying his compliments to the Society, Mr. Fisher stated some facts regarding the local airport. More than 66,000 landings were made there last year, with an estimated 45,000,000 air-mail letters passing through Oakland Airport. It is expected that close to 100,000 landings will be made there during 1929, said Mr. Fisher.

His words were followed by brief remarks by Sidney B. Shaw, present Chairman, and E. C. Wood and W. S. Penfield, past Chairmen, of the Northern California Section, and Ethelbert Favary, who extended to those present the greetings of the Southern California Section.

E. B. Fleld, president of the Oakland Chamber of Commerce, then made some observations on aeronautic progress in Oakland territory. After introducing a number of visitors, Mr. Fisher presented to the members George Posey, Alameda County engineer, who is known as the "father of the Alameda-Oakland tube." Mr. Posey briefly summarized the relation between automotive traffic and such underground transportation as is afforded by reinforced-concrete vehicular tunnels.

CONTESTANTS IN THE LADIES' RACE

At the Left Is Marvel Crosson, the Winner, from Los Angeles. Maxine Dunlap Is Known as the Flying Stenographer of Oakland

At this point Howard Baxter announced the winners of prizes and trophies for the afternoon contests, and a committee of the wives of members of the Oakland Airport Association selected the best-dressed pilot. Additional prizes such as a wooden dumbbell and a large oil can, suitably inscribed, were presented "in the spirit of good fellowship" to pilots who were considered to have pulled the prize bones.

The last number inside the hangar was a five-reel motion-picture shown by Lieut. Commander F. B. Connell, illustrating the aviation training given by the Naval Reserve, operating from 15 aviation-squadron bases near large universities where ground-school courses are given. A paper on this subject that was prepared by Commander Connell, who commands the United States Naval Reserve aviation base at Oakland, was presented by title only. The paper on the history and development of aviation engines, by C. L. Stroud, was also omitted.

Night Landings Demonstrated

The closing attraction was an exhibition of night flying with the trimotored Standard of California and a Boeing mail plane of the Pacific Air Transport. Foster V. Tompkins took off and landed in the big Ford plane twice, first by the 30,000,000-cp. lights of the field and then by the landing-lights of the plane itself with the field-lights off. In the final flight, the Boeing plane went up with the field-lights on. Two buglers on the roof of Hangar No. 1 sounded Taps, and the airport lights went out. Then came a great burst of light above as a parachute flare was released from the plane, which made a safe landing that won

a hearty ovation from the spectators.

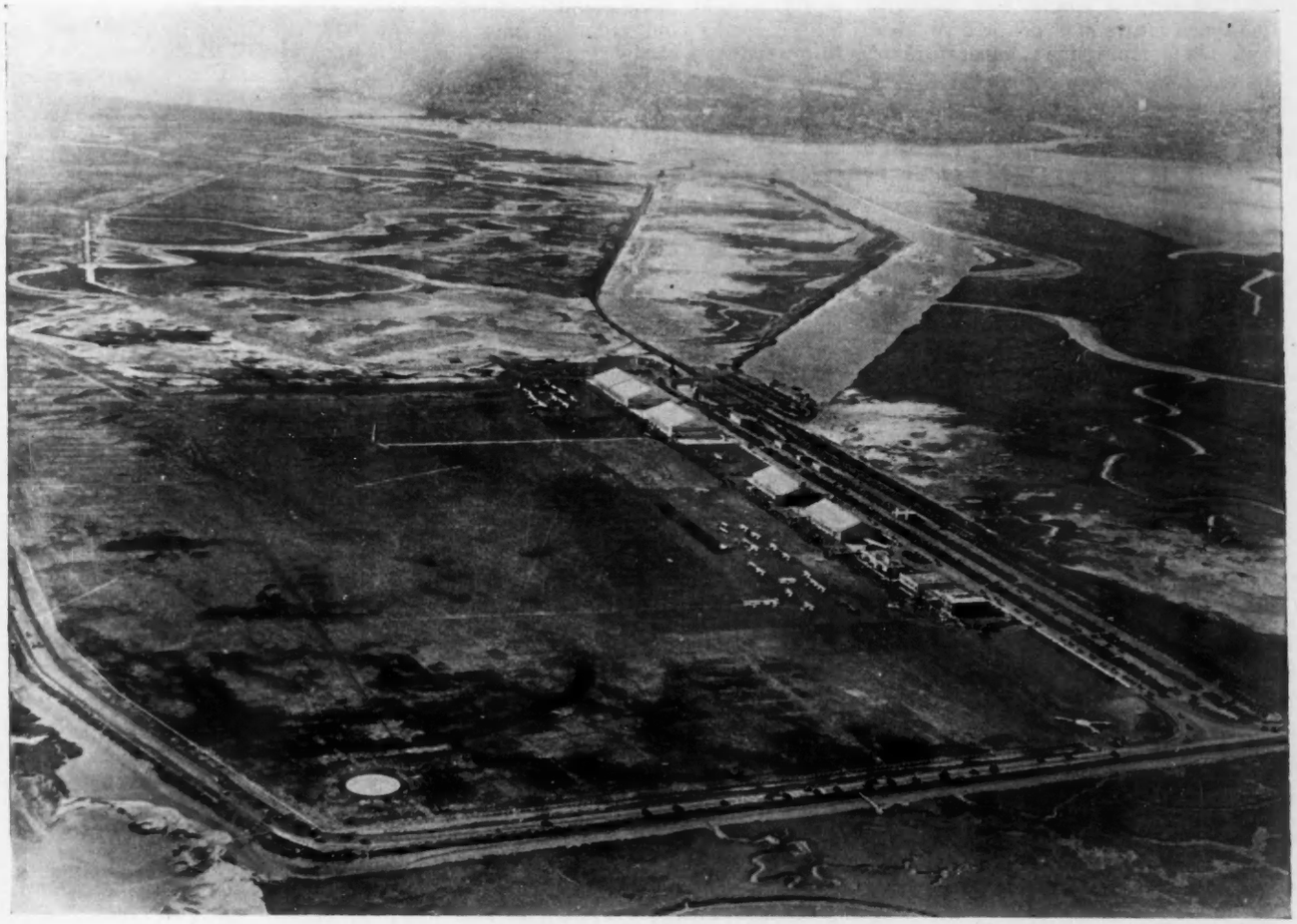
Herbert L. Miller, of the Sterling Motor Truck Co. of California, East Bay Vice-Chairman of the Section, acted as executive chairman of arrangements, and was largely responsible for the success of the affair. Howard Baxter, president of Howard Baxter Automotive Service, was chairman of the Executive Committee, E. C. Wood was chairman of the San Francisco committee, and W. S. Penfield had charge of the committee on transportation, decoration, and parking. Transportation of members and needed equipment was furnished by the Key System Transit Co., Fageol Motors Co. and the American Car & Foundry Motors Co. Joseph F. Long and Referee L. S. Nagle, the official observer of the National Aeronautic Association and the Federation Aeronautique Internationale, had direct charge of the races. An ambulance, firemen and 35 policemen were provided for the occasion.

Aircraft-Engine Development

Past, Present and Future Engines Discussed at Northern California Section Meeting

SINCE the beginning of the development of aircraft, engineers have been concerned in the production of light, reliable and economical engines for aircraft propulsion. The paper on Aeronautical Engines presented by C. L. Straub at the meeting of the Northern California Section held May 9 at the Engineers Club, San Francisco, dealt with major phases of American and foreign aircraft-engine development in general terms, the time available being insufficient to permit more than a passing reference to the more interesting thermodynamic and technical phases of this development. Mr. Straub, who is aeronautical instructor of the 12th Naval Reserve Ground School, showed numerous lantern-slides illustrating engine history and development. He remarked that, in the light of all subsequent development, the work of Charles M. Manly, past-president of the Society, who built the first internal-combustion engine that propelled an airplane, stands out as the product of an inspired master.

At the request of Chairman S. B. Shaw, announcement was made that the following Section officers had been elected for the coming year: Chairman, Horace L. Hirschler; Vice-Chairman, Edward H. Zeitfuchs; Treasurer, Fred L. Sargent; Secretary, William S. Cro-



AERIAL VIEW OF THE AIR MEET AT OAKLAND

The Start and Finish Line Runs from the Middle Hangar to the Pylon in the Left Center of the Photograph. The Two Airplanes at the Take-Off Line in the Foreground Are Those of Marvel Crosson and Maxine Dunlap, Ready for the Start of the Second Race. Planes of Other Contestants Are Grouped Nearby. Exhibition Planes Belonging to Various Oil Companies Are Grouped in the Further Corner of the Field. Near Them Is the Channel for Seaplanes Connecting with Oakland Estuary and Through It to San Francisco Bay. An Elongated Runway in the Direction of the Prevailing Wind Extends Beyond the Photograph to the Left. Cars Are Parked Side by Side in Five Solid Rows for a Distance of About One Mile at the Right of the Field, and Many Spectators Came by Motorcoaches Provided by the Committee. The Attendance Was Estimated by the Oakland Police to Be 50,000

well. Howard Baxter was elected Chairman of the East Bay Section.

Although Mr. Straub acknowledged that prophecies are always subject to criticism, he nevertheless predicted that future airplane engines will tend toward still higher compression-ratios and mean effective pressures in the neighborhood of 200 lb. per sq. in. For reasons of increased reliability and economy of operation and their attendant increase of distance of flight, he said that aviation fuels in the future will be more carefully refined, selected, blended and doped than at present, so as to permit extremely high compression and much better fuel economy. He remarked further that ultimate compression-ignition will be more of the mixed-cycle type in which a proper fuel, doped so as to preclude the possibility of preignition, will be introduced into the cylinders and compressed to high pressures. Ignition will be caused by the injection of a relatively small measured quantity of special fuel, the ignition temperature of which will be lower than the compression temperature of the engine.

Mr. Straub referred to alcohol fuels blended with ether and benzol that are in automotive use and said that, although the number of British thermal units contained per pound of such fuel represents only approximately two-thirds the heat value of gasoline, it has been demonstrated frequently that 1 lb. of alcohol of a heat value of approximately 12,500 B.t.u. can and will develop as much power as 1 lb. of gasoline of a heat value of 20,000 B.t.u. This is because of the lesser quantity of air required for combustion and the consequent reduction in volume of heat-robbing nitrogen carried through the engine, and also because of the much higher compression-pressure possible with such fuel. He commented upon these data to the affect that the interesting possibility of operating an engine on pure oxygen is thereby suggested, instead of on a mixture comprising 23 per cent of oxygen and 77 per cent of nitrogen as at present. Such practices would, he said, make possible astonishing economies and reduce engine and fuel weights per mile flown to a point not within our present knowledge.

Aeronautic Division Formed

Southern California Section also Studies Airplane Stability and Small Engines

TWO PAPERS were presented at the meeting of the Southern California Section held at the Los Angeles City Club, Los Angeles, May 10. The Stability of Airplanes was considered by Lieut.-Commander Laurence B. Richardson, Construction Corps, U. S. N., and Airplane Engines of 125 Hp. and Less were illustrated and commented upon by N. N. Tilley, chief engineer of the Kinner Airplane & Motor Corp., Los Angeles, whose aim was to bring out some of the structural differences in these small powerplants.

An audience of about 300 members and guests greeted the speakers and, following the request of Chairman Leigh M. Griffith, announcement was made of the names of the Section officers for the coming year, as follows: Chairman, William H. Fairbanks; Vice-Chairman, Fred C. Patton; Treasurer, J. Jerome Canavan; Secretary, C. H. Jacobsen. The members of the Executive Committee are Eustace B. Moore, Eugene Power and Ethelbert Favary.

Officers of the Aeronautic Division of the Section, elected for the coming year, are: Commander E. E. Wilson, Chairman; Harry A. Miller, Leigh M. Griffith and Donald A. Hall, Vice-Chairmen; J. Jerome Canavan, Treasurer; and G. F. Vultee, Secretary.

Preceding the papers a brief address was made by J. A. H. Kerr, vice-president of the Los Angeles Chamber of Commerce and vice-president of the California Development Association, both of which organizations are very active in the promotion of aviation from the civic point of view. As explained by Mr. Favary, the occasion was memorable in that it was the first meeting of the newly organized Aeronautic Division of the Section, and Mr. Kerr's address related largely to the field of development which is available for the Division's activities. He quoted numerous statistics in support of this statement that California is becoming known as the most "air-minded" State in the Union.

Stability of Airplanes

Commander Richardson said in part that stability is considered the most difficult problem in connection with the theory of airplane design, because of the obstacles it presents to mathematical treatment and the difficulty of obtaining reliable information on the flying qualities of airplanes; but he mentioned that, because of the work already done by the mathematicians and by means of wind-tunnel and flight tests, it is now possible to predict with considerable accuracy the stability of a given design. He defined stability as that property of a body which causes it to return to an original condition of equilibrium or steady motion when disturbed therefrom. However, this definition is incomplete in its application to the airplane because several kinds of stability are recognized.

He stated that, if an airplane is following a straight path and is disturbed from it as by flying into an up-current of air, it may act in any one of four ways. First, it may return to the original course without oscillation, thus showing the most complete stability. Second, it may oscillate with decreasing amplitude until it returns after a few heavily damped oscillations to the original path, thus showing stability of a lesser degree. Third, it may make a series of oscillations of gradually increasing amplitude, thus showing static stability but lack of dynamic stability. Fourth, it may diverge steadily from the original path, thus showing static instability and into which condition no question of dynamic stability enters. These four conditions indicate that an airplane is statically stable longitudinally when it tends to return toward the condition of steady flight, and that it is dynamically stable when the oscillations of the statically stable machine are damped so that there is actual return to the original condition.

The subdivisions of the subject as treated by the speaker were the statical and the dynamical longitudinal stabilities, lateral and directional stability, autorotation and spinning, and special consideration of the flat spin.

Small Airplane Engines

As stated by Mr. Tilley, what constitutes a small engine for an airplane is largely dependent upon the type of airplane for which it is intended. For power gliders, 10 to 15 hp. is thought ample. Light airplanes seem to require 30 to 60 hp. Small civilian training or sport planes are available that have 80 to 120 hp. Military training planes and many commercial and passenger-type airplanes seem to require from 150 to 250 hp. Most military planes, many mail planes and transport planes use single engines up to 600 hp., or multiple engines of 150 hp.

The airplanes using small engines compare favorably in performance with planes previously available that have much larger powerplants, said Mr. Tilley. On account of improvement in construction, the performance of airplanes having the small powerplants is at least twice as good as that of the familiar war-time training-planes. Landing-speeds are generally well below 40 m.p.h. Rates of climb up to 1000 ft. per min. and top speeds of over 100 m.p.h. are usual for many of the airplanes. A speed of 186 m.p.h. has been attained with one of these small engines in a small racing plane.

The speaker said that the requirements of the airplane powerplant are: light weight, low rate of fuel and oil consumption, reliability and durability,

smooth and flexible operation and compactness, so that the engine offers rather small resistance to speed through the air when combined with the airplane. Light weight of powerplant and low rate of consumption of fuel and oil are essential to obtain the maximum disposable load. Light weight is obtained by compact arrangement, extensive use of aluminum alloys and high-strength steels, and high power per unit of displacement. The high power is obtained by high torque rather than high rotative speed, since propeller efficiencies are highest for high torque and low rotative speed.

The questions asked and answered during the discussion related largely to further details of the points brought out in the papers.

Hassell Tells of Flight

Describes Experiences on Trip Ended in Greenland at Chicago Section Meeting

NATURE favored the Chicago Section with a beautiful day for its outdoor final meeting of the season, and 102 members and guests assembled at the Municipal Airport, where they were taken for short flights in various aiplanes that were available. No accidents or airsickness marred the occasion.

Following the very interesting afternoon at the airport, the party assembled for dinner at the City Club at 6.30 p. m., a few additional members who could not participate in the outdoor activities swelling the attendance to 115.

At a short business meeting preceding the technical session at which Bert A. Hassell, whom Greenland made famous, was the principal speaker, an election of officers of the Section for next season resulted as follows:

Chairman, D. P. Barnard, 4th
Vice-Chairman, G. A. Buckbee
Secretary, John O. Eisinger
Treasurer, E. W. Stewart

J. W. Tierney, of the Electric Storage Battery Co., Chairman of the Section, who presided, read a telegram from Lieut. A. J. Williams, U. S. N., who was scheduled as a speaker, reporting that bad weather had prevented his flying to Chicago for the meeting. The Chairman also read a letter received from the Meetings Department of the Society relating to the Summer meeting and appointed Edward R. Barnard and John O. Eisinger a committee of two to work out a plan for a Section stunt at the Saranac meeting. Then he introduced Mr. Hassell, of last year's Rockford-to-Stockholm flight, which terminated in Greenland and kept the Country in anxious suspense for a week before the world received the welcome news from the University of Michigan meteorology station at Strom Fjord that he and "Shorty" Cramer were safe.

In Greenland's Icy Mountains

In the course of an extremely interesting running narrative of the flight, the landing on the edge of Greenland's ice-cap, and five days' walking around the mountainous heads of fjords to find Dr. Hobbs' camp, Mr. Hassell explained the object of that flight. It was not merely to add another to the list of successful transatlantic fliers, but rather to demonstrate the practicability of a short route from the inland United States to northern Europe with an over-water portion barely 600 miles long. As Mr. Hassell pointed out, the real importance of such a route would lie not only in minimizing the hazard of flying over water for long distances but also in the reduced quantity of fuel to be carried, since a number of stops for refueling could be readily arranged at intervals of 500 or 600 miles, corresponding to the average American air-mail hops. Such a flying plan would make possible the carrying of real pay-loads between the continents, said the speaker.

Proceeding with his amusing as well as interesting narrative, Mr. Hassell told the story of how he and Cramer flew to Greenland, made a safe landing on the ice and, innocent of their actual location and the difficulties of the terrain, started in high glee and without adequate preparation upon what they expected would be a one-day's walk to Mount Evans to get a 5-gal. can of gasoline for the airplane. Without a compass and blocked repeatedly by fjords that could not be crossed on the ice, they tramped for five days seeking their objective, and had to subsist on canned pemmican and fresh ptarmigan which they shot with an old rifle. At last, however, they sighted a small vessel, sailed by a caribou hunter who espied the smoke from a small fire they had started, and were taken aboard and to Dr. Hobbs' camp.

Plans for This Year's Flight

Very hearty acknowledgment of the hospitality accorded them by both the American meteorologists and the native Esquimos was given by Mr. Hassell, who said in conclusion:

We do not believe that it is essential to start a flight this year or next year or any other year just to try to race to another country or to Europe at any certain speed for any certain prize. But we do believe we can help materially by showing the possibility of using the northern route to carry a pay-load. When one flies from Newfoundland to Ireland over 1900 miles of water he carries gasoline for the whole distance and two or three fountain pens for a pay-load, but when he flies from Chicago over the North into the central part of Europe, he can make jumps of 500 to 600 miles, which are equivalent to those on our air-mail routes, and can carry a normal passenger-load with an adequate gasoline supply. That is the only thing we had to prove, the only thing that we hoped to give to commerce.

The future plans are to make nine stops between Chicago and the Norwegian coast, flying up to the Soo, to Cochrane, to Rupert House, across Ungava to Greenland, from there to Reikjavik, Iceland, and then to the Faroes. From there we can fly to either Bergen or Trondhjem in Norway and thence to central distributing points. Copenhagen represents in Europe what Chicago represents in the United States as an air center.

There are great advantages in using this proposed route rather than flying that long distance over water which cuts down the pay-load that can be carried. This year we hope that our luck will be much better. We want to start this year and move that ocean airport from New York City down to the foot of Lake Michigan in Chicago, where it belongs.

Interesting aeronautical experiences were related also by Carl V. Vickery, of the Gray Goose Air Lines; by Chairman Tierney, and by Prof. M. E. Wells, of the Armour Institute of Technology.

Air-Transport Described

Methods, Night Flying and Pan-American Development Hold "Met" Section Attention

THREE EXCELLENT papers on airlines, one supplemented with a two-reel motion picture of the transcontinental air-mail service from New York City to Dallas, Tex., held the absorbed interest of the 350 members and guests at the final dinner-meeting of the Metropolitan Section on May 23. The meeting was held in the Park Central Hotel and was opened by Chairman S. R. Dresser with announcements of the election of officers for next year, an expression of the appreciation of the Section for the wholehearted work done by the retiring officers and by D. Beecroft as Chairman of the Papers Com-

mittee, and announcements regarding special-train service to the Summer Meeting, accommodations afforded by the cottages at Saranac and the stunt being planned by the Metropolitan Section.

The new officers elected are: Chairman, George R. Round; Vice-Chairman, John F. Creamer; Vice-Chairman, Aeronautic Division, J. C. Hunsaker; Treasurer, Erwin H. Hamilton; Secretary, Walter S. Peper.

Comparative membership figures at the close of the season were given as: Detroit Section, 1040; Metropolitan, 880; applications for membership from Oct. 1, 1928, to April 30, 1929: Detroit, 137; Metropolitan, 122.

When the good dinner had been concluded with ice cream and coffee, Mr. Dresser turned the meeting over to Capt. E. S. Land, Chairman of the Aeronautic Division.

Three Airline Developments

Capt. Lester D. Seymour, general manager of National Air Transport, Inc., gave a valuable and informative review of the four-years' development of the New York City to Dallas airline and told of some of the changes in methods made when the New York-Chicago mail contract became effective, when the air-mail rate was reduced from 10 cents to 5 cents for the first ounce, and as experience showed that the distance flown per trip and the time between overhauls could be extended.

After delivery of the paper, the audience watched with absorbed interest the motion pictures of the operation of the planes over the whole route, in which emphasis was laid on the time of 20 hr. from New York City to Dallas.

W. E. Boeing, of the United Aircraft & Transport Corp., author of the second paper, on Night Flying with Mail, Express and Passengers, was unable to be present and the paper was read by George Wheat. It dealt with airway lighting, radio beacons, and radiophone communication between the ground and planes in the air, and concluded with the prophecy that passenger transports of the future will be larger, faster and more comfortable than were dreamed of a few years ago.

J. T. Tripp, president and general manager of the Pan-American Airways, presented the third paper, in which he told of the inauguration of flying services between the Southern States, the West Indies and Central American republics.

Aircraft Division Report Reviewed

Bearings Division Requests Change in Wheel Bores for Inner and Outer Bearings

IN CONNECTION with the proposed specification for Airplane Landing-Wheel Hubs and Axles with anti-friction bearings, that was published on p. 539 of the May issue of THE JOURNAL, a request was made at the Aircraft Conferences in Detroit in April that the Ball and Roller Bearings Division of the Standards Committee be given an opportunity to review the specifications so far as the bearing sizes are concerned before the reports is acted upon by the Standards Committee and the Society.

This proposal was accordingly reviewed by the Division at its meeting in New York City on May 21, at which data submitted and discussed indicated that, with slight changes in the bearing outside diameters allowed for the three largest sizes of bearings, it will be possible for the ball-bearing manufacturers to meet the proposal with ball-bearing layouts.

The subject was discussed at length from the points of view of the landing-wheel, airplane, roller-bearing and ball-bearing manufacturers, it being indicated by the wheel representative present that if it is possible to make the changes without seriously affecting the wheels in view of the consideration that has already been given the whole matter, the wheel manufacturers would undoubtedly be glad to consider the request. It was then voted to request the Aircraft Division of the Standards Committee, in presenting this report to the Standards Committee and the Society, to change the wheel bores (*B*) for the inner bearings of the 2.500, 3.000 and 3.750-in. axle-diameters to 4.249, 4.874 and 5.9365 in. respectively and to make similar changes in the wheel bores (*G*) for the outer bearing for 2.500 and 3.000-in. axle-diameters.

TABLE OF BEARING DIMENSIONS

Outside Diameter	Bore Diameter	Bearing Width	Corner Radius
1.625	0.750	15/32	0.040
2.3125	1.250	37/64	0.040
2.6875	1.500	5/8	0.060
3.375	2.000	3/4	0.060
4.250	2.375	27/32	0.080
4.875	3.000	31/32	0.080
5.9375	3.750	1 1/8	0.120

Dimensions are in inches. Bore and outside diameter tolerance for all sizes is plus 0.001, minus 0.000 in.

These changes will provide for ball-bearing layouts as well as roller-bearing layouts for bearings having even fractional dimensions as shown in the accompanying table, which is given for information only and is not presented for inclusion as a part of the specification.

Members of the Ball and Roller Bearings Division present at the meeting were H. E. Brunner, S. K. F. Industries, Inc., Chairman; G. R. Bott,

(*Concluded on page* 670)

News of Section Meetings

(*Continued from p. 573*)

A motion was passed applying for the formation of such a Section and signed by 18 members of the Society present.

B. H. Eaton, of the Bell Telephone Co., acting secretary, reported that the meeting was well attended and that encouraging interest was shown. H. V. Thaden, of the Pittsburgh Metal Aircraft Corp., was added to the membership of the organization committee, which was instructed to investigate cooperation with the Engineers' Society of Western Pennsylvania in regard to the problems of proposed headquarters and secretarial work.

Names of some of the members interested in organizing a Section in Pittsburgh were given in the report of a previous meeting printed in the S.A.E. JOURNAL for May, p. 556.

Spirited Debate on Race Rules

Round-Table Discussion at Indiana Section Meeting Brings Out Opposed Views

CERTAINLY there was no lack of interest in the subject of the evening among the 200 members and guests at the Indiana Section meeting on May 18, following the dinner at which 171 sat amicably at the table before the fireworks began. The topic that drew one of the Section's largest gatherings and resulted in an exciting meeting in which no efforts of a chairman were required to draw out the opinions of diffident speakers was the Cars and Rules for the 500-Mile Race for 1930. Each speaker was limited to six minutes, and more than a score gave their opinions of the proposed rules and the cars that could be built to compete under them. These rules propose a maximum piston displacement of 366 cu. in., limit the number of valves to two per cylinder, and bar supercharging except on two-cycle engines.

The meeting divided into two camps, some of the engineers maintaining that the rules are workable, might bring out new ideas in racing cars designed closely along the lines of stock production-cars, and that passenger-car factories might cooperate with those who desire to alter stock cars or build new cars to compete in the Indianapolis race under the proposed rules.

Arguments along these lines were made by Col. William G. Wall, Thomas J. Litle, Jr., Waldo Stein, Ralph Teetor, Fred S. Duesenberg, Edward D. Herrick and others who were scheduled to start the ball rolling with informal talks. The general sentiment expressed was that adherence to the proposed rules might result in advancement in passenger-car design in the direction of lightness and efficiency disclosed in racing cars of new design.

In the other camp Harry Miller and many famous racing men lined up in opposition to the rules. Bert Dingley, elected Chairman of the Section at the meeting, read a letter from Mr. Miller expressing his regret that he could not attend the meeting and pronouncing the rules a long retrograde step to the type of cars used on the race track years ago. He criticized the restriction to two valves per cylinder, the barring of supercharging and the proposal to restrict the number of carbureters to two, a dual carbureter to be counted as two. He objected also to rules that would bring about a return to the type of car in which mechanics would ride with the drivers and risk their lives.

Louis Schwitzer also protested against the restriction against supercharging. He asserted that valuable experimental work is being done on supercharging small engines in racing cars; that almost all passenger-cars are excessively powered, using only about one-third of the engine power for most of the driving, but carrying excess weight of engine and of chassis to support the weight and stresses imposed by the engine. He said that these are important factors in the motorcoach and motor-truck fields in which a large opportunity exists for the supercharger, as smaller and lighter engines are wanted so that the maximum pay-load can be carried.

Interests of the owners and pilots who have invested half a million dollars in small racing cars but were not invited to the meeting of the Contest Committee of the American Automobile Association and the race-track owners at which the new rules were proposed were championed by Ralph DePalma. In an eloquent appeal on behalf of the men who have supported racing without realizing commensurate returns, he declared that it is futile to expect much support from the automobile factories in preparing cars to race under the new rules or any others, as with a freak car and some luck an outsider may beat the best of the so-called semi-stock cars. DePalma's and Mr. Schwitzer's remarks drew great applause that seemed significant of the majority sentiment of the attendants.

Others who bespoke more consideration of the drivers and reconsideration of the proposed rules were Thomas Milton, Harry Hertz and Wade Morton.

A set of rules based on fuel and oil allowance, with all classes of engine and chassis admitted, might be productive of the most helpful sort of competition and the greatest progress of the industry, according to suggestions made by Louis Chevrolet, Charles Crawford and Lee Oldfield.

At a very short business session following the dinner and preceding the animated discussion herein narrated, an election of Section officers for the coming season resulted as follows:

Chairman, Bert Dingley
Vice-Chairman, Fred S. Duesenberg
Treasurer, Charles A. Trask
Secretary, Harlow Hyde.

Pennsylvania Plays Golf

THE PENNSYLVANIA Section 1928-1929 season was brought to a close with the annual golf tournament, held this year at the Baederwood Country Club, about 25 members playing-off in the Blind Bogey Tournament arranged by Cap Risley. Following the tournament, a special dinner was served in one of the private dining-rooms of the Club, at which prizes for the tournament were announced.

The prize for the largest gross score went to F. O. Paul; that for the lowest gross score went to C. E. Dwyer, who turned in a card of 85. The winner of the Blind Bogey Tournament was decided by drawing from a hat containing the names of all players making a net score of between 70 and 80, the winner being E. R. Gurney. The meeting was officially adjourned following dinner.

Outboard Boats N. E. Subject

DEMONSTRATIONS and exhibitions at the Boston Yacht Club and a dinner at the Walker Memorial Building, Massachusetts Institute of Technology, were included in the joint meeting of the New England Section with

the New England Outboard Motor Boat Association, on the afternoon and evening of May 22. About 50 attended the afternoon events and 75 the meeting in the evening, according to Secretary W. M. Clark.

Section officers were elected as nominated by the regularly appointed committee, the following men being named: Chairman, W. M. Clark; Vice-Chairman, Albert Lodge; Secretary, H. B. Hawk; and Treasurer, V. J. Ogilvie.

Three papers were read on various subjects connected with outboard-engine boats. Frank Wigglesworth reviewed the history of outboard racing and gave such details of race-meet operation as methods of classifying, timing and scoring.

The development of outboard engines was traced in a paper by Mr. Wilkinson, beginning with the first engine of this type in 1890 and the first successful model, in 1910, which developed 1½ hp. at 900 r.p.m. In discussing the present engines, developing as much as 32 hp. at 6000 r.p.m., he dwelt on the efficiency of the two-cycle type and problems involving the design of carbureters, lubrication, inlet systems and spark-plugs. Mr. Wilkinson closed with his views on possible future developments.

Jacob Dunnell took up the subject of hull design, which he said depends mostly on trial and error, since no formulas or text books on the subject are available. Tank tests of models are unsatisfactory because of the small size of the models and the speed of towing necessary to produce duplicate results. Mr. Dunnell believes the trend of design to be away from the V-bottom type and that the round bottom is gaining because of better stability and ease of turning. The concave design handles the spray better. The center air-cushion and lower outside-chine give better stability. Low chines are bad in turning.

Resistance losses were allocated in percentages by the author as follows: Propeller, 35; wave resistance, 25; air resistance, 10; and skin friction, 30. He believes that a greater reduction can be made in the wave resistance than in any other of these losses.

Diesel Engine Development Reviewed at Buffalo

HIGH-SPEED Oil Engines was the subject of a paper presented at the monthly meeting of the Buffalo Section on May 10 by Edwin C. Magdeburger, aide on Diesel engines for the Bureau of Engineering of the Navy Department. Many questions asked of the speaker by various of the 71 members present showed great interest in the subject. They dealt with oil engines for use in submarines, surface ships, motor-trucks, motor-coaches, power stations and aircraft; with the fuel used, the possibility of using heavy oil in standard gasoline engines and of supercharging heavy-oil engines, fuel consumption per horsepower-hour, cost of Diesel engines per horsepower, operating economy, reduction of fire hazard, and so forth.

Chairman E. W. Kimball, who convened the meeting, announced the death of John C. Talcott, chief engineer of the Pierce-Arrow Motor Car Co. and a member of the Section. The meeting agreed that the Secretary should send a letter of condolence from the Section to Mr. Talcott's family.

Officers of the Section for next season were elected as follows:

Chairman, Gustaf Carvelli, of the Curtiss Aeroplane & Motor Co.

Vice-Chairman Donald Cox, of the Pierce-Arrow Motor Car Co.

Secretary, William Edgar John, of the Buffalo Gasoline Engine Co.

Treasurer, Marsden Ware, of the Curtiss Aeroplane & Motor Co.

Following the brief business meeting, the technical session was conducted by Mr. John.

Standardization Activities

(*Concluded from p.* 651)

for the roller and ball types, but it was generally agreed that if this could be avoided it would be very desirable to do so. A Subcommittee on Ball Bearings and a Subcommittee on Roller Bearings were then appointed, each to study the problem from their particular point of view. Upon arriving at their conclusions, the two Subcommittees considered the entire project jointly and finally worked out a proposed single series of dimensions that included both the roller and ball types of bearings. The proposal was referred to the electric-motor manufacturers through the N. E. M. A. and the Society has been informed unofficially that the proposal is acceptable to them. Definite action was expected to be taken by the N. E. M. A. at its Convention in May, 1929.

Approved for Submission to Sponsors

The Division approved its original proposal at a meeting of the Division on May 21 but, as the project was a special assignment to the Division and the members did not feel that the extended series should be published as an S.A.E. Specification, they referred it to the Sectional Committee on Ball Bearings for which the Society is a sponsor, with the recommendation that it be published as American Recommended Practice under the procedure of the American Standards Association.

The Sectional Committee, at its meeting on the day following that of the Ball and Roller Bearings Division, accepted the recommendation of the Division and approved its submission to the sponsors for their approval and the publication of the report without waiting for the publication of the Sectional Committee's uncompleted general report on ball bearings.

The following tables are therefore submitted by the Ball and Roller Bearings Division to the Society for approval as American Recommended Practice, especially for electric-motor applications, in accordance with the original request by the N. E. M. A.

The report is in two parts and is intended to apply for both the roller and ball types of bearing. The first part of the report includes all of the annular wide-type bearings in the S.A.E. Standard for Ball Bearings given on p. 257 of the 1929 issue of the S.A.E. HANDBOOK, and the second part, or the extended series of these bearings, is given in the accompanying table. The extended series is intended to include only the light and medium series corresponding in diameters to the 200 and 300 series of ball bearings, it being generally agreed that a heavy series corresponding to the 400 series of ball bearings is not desired at this time.

WIDE BEARINGS, EXTENDED SERIES

Light Series		Medium Series	
No.	Width, In.	No.	Width, In.
5224	3	5324	4⅛
5226	3⅛	5326	4⅜
5228	3¼	5328	4½
5230	3½	5330	4⅞
5232	3⅞	5332	5¼
5234	4⅛	5334	5½
5236	4¼	5336	5¾
5238	4½	5338	6
5240	4¾	5340	6½
5244	5¼	5344	7
5248	5¾	5348	7½
5252	6¼	5352	8
5256	6½	5356	8½
5260	7		
5264	7½		

Note.—These bearings are normally a double-row type of construction. The tolerances shall be the same as for the corresponding sizes in the light, medium and heavy series of single-row annular ball-bearings.

Personal Notes of the Members

Peper Leaves Yellow Coach

Walter S. Peper has been named regional sales director for New York and New Jersey of the Curtiss Flying Service, Inc., of New York City. Prior to this appointment, he was in charge of Eastern Service, Yellow Coach Div., General Motors Truck Co., which service he organized and of which he has been in complete charge since 1926. His affiliation with the Yellow Coach Mfg. Co. began in 1925, when he entered its service department.

The early part of Mr. Peper's engineering experience was largely in the aeronautic field. In 1917 he served the General Vehicle Co., later known as the Aeronautical Engine Corp., in Long Island City, N. Y., as a mechanical draftsman, and in 1918 he worked in a similar capacity for te Lawrance Aero Engineering Corp., in New York City. In the spring of 1918, he joined the United States Naval Reserve Flying Corps and trained

WALTER S. PEPER

at the Aviation School, at Great Lakes, Ill. At the close of the World War he enrolled as a student in mechanical engineering at the Brooklyn Polytechnic Institute and while continuing his studies acted as assistant research engineer for the Fifth Avenue Coach Co., of New York City. In 1923 he was graduated from "Poly" and assumed the position of junior engineer with the Climax Engineering Co., located at Clinton, Iowa. The following year marked the beginning of his association with the Yellow Truck & Coach Mfg. Co.

Mr. Peper joined the Society as a Junior Member in 1919 and was transferred to Member grade this year. An active cooperator in Metropolitan Section affairs since becoming a Section member in 1927, he has conributed valued assistance to Section membership work. In 1927 he served on the Metropolitan Section Membership Committee and in 1928 was elected Chairman of that Committee. At the May meeting of the Section he was elected Secretary for the coming year.

Ammerman's New Position

K. J. Ammerman has resigned as assistant to C. S. Sale, president of the American Car & Foundry Motors Co., in New York City, to assume the duties of sales manager for the Comet Engine Corp., of Madison, Wis. He will be located in New York City.

Following graduation from Lafayette College in 1916, with the degree of mechanical engineer, Mr. Ammerman joined the Simplex Automobile Co., at New Brunswick, N. J. (later the Wright-Martin Aircraft Corp.) as engineer of standards. In 1917 he enlisted in the United States Air Service, being appointed a second lieutenant, and was assigned the duties of pilot-instructor. In 1919 he re-assumed his position with the Wright-Martin Aircraft Corp., but resigned a year later to establish a connection with Brewster & Co., of Long Island City, N. Y., as mechanical engineer. He subsequently joined the Packard Motor Car Co. as sales manager of the Newark, N. J., branch and remained in this position until 1926, when he became identified with the American Car & Foundry Motors Co.

Mr. Ammerman became a Member of the Society in 1927 and joined the Metropolitan Section the same year. His thorough knowledge of standards has been of great value to the Society. This year he is the S.A.E. representative on the Mechanical Standards Advisory Council.

Motor coach Design is the title of a comprehensive technical paper presented by Mr. Ammerman at the 1927 Transportation Meeting of the Society and published in the December, 1927, issue of the S.A.E. JOURNAL. Discussion of the paper appeared in THE JOURNAL for March, 1928.

Thaden Sells Aircraft Company

News of special interest to those in aeronautical circles came with the announcement that H. V. Thaden had recently sold out his interests in the Thaden Metal Aircraft Corp., at San Francisco, to the Pittsburgh Metal Airplane Co. Mr. Thaden, who was for-

H. V. THADEN

merly vice-president and general manager of the Thaden company, now holds a similar position with the Pittsburgh Metal Airplane Co.

Active in aeronautics since the beginning of his engineering career, Mr. Thaden received his basic experience in the Air Service of the United States Army. He joined the Air Service in 1917 and served two years as second lieutenant. In 1920 he was appointed to the staff of the National Advisory Committee for Aeronautics, his specific duties being wind-tunnel, laboratory and free-flight testing. He studied aeronautical engineering at the Massachusetts Institute of Technology and also at the Imperial College of Science and Air Ministry in England. In 1923 he became affiliated with the Aircraft Developments Corp., of Detroit, as aeronautical engineer and was responsible for the development of the Ford Airship mooring mast.

Mr. Thaden joined the Society in 1921 as a Junior Member and was transferred to the grade of Associate

(*Continued on p.* 36)

John C. Talcott

A LIFE of gratifying achievement came to an untimely close on April 27 when John C. Talcott, chief engineer of the Pierce-Arrow Motor Car Co., succumbed to pneumonia at his Buffalo home.

Mr. Talcott was born in Buffalo on July 2, 1886. Following his education at the public and high schools of that city, he attended Cornell University and in June, 1909, received the degree of mechanical engineering from that institution. He thereupon accepted his first position with Pierce-Arrow, a connection that endured through the remaining 20 years of his life. His flair for precise and original work won him advancements through the positions of assistant experimental engineer and experimental engineer to the post of chief engineer of the company. It is understood that Mr. Talcott is credited with the major share of the experimental work that culminated in the adoption by the Pierce-Arrow Motor Car Co. of the dual-valve system.

Mr. Talcott's many associates in the organization learned to respect him for his engineering ability, industry, progressiveness and loyalty, and to regard him highly as a friend.

In April, 1917, Mr. Talcott was elected to Member grade in the Society. He is survived by his widow, Mrs. Marguerite L. Talcott, and two daughters.

Eugene A. Riotte

THE INDUSTRY has sustained the loss of an American pioneer in marine and automobile internal-combustion engineering, and the Society the loss of one of its early members of prominence and great ability, in the passing of Eugene A. Riotte.

Taken ill last October and forced thereby to retire from active business a few months later as president of the Standard Motor Construction Co. of Jersey City, N. J., Mr. Riotte passed away in a hospital in Miami, Fla., on April 4. His loss is deeply felt by the organization of which he was the head for nearly 30 years, and by a host of friends that he had made throughout the Country.

Born at Oakland, Calif., in June, 1879, Mr. Riotte began designing and building marine engines in 1896. During four years in the infancy of the automobile industry in this Country he was connected with the United States Long Distance Automobile Co., in the very early years of the 20th Century. Later, this company became the Standard Motor Construction Co. and confined its efforts to building marine gasoline and oil engines, with Mr. Riotte at the helm as president and general manager.

Mr. Riotte became a Member of the Society in 1917, and during that and the following year served on the Marine Division of the Standards Committee.

Richard Elwood Bissell

A VICTIM of the Cleveland Clinic disaster which took a toll of over 100 lives, Richard Elwood Bissell, chief engineer of Thompson Products, Inc., Cleveland, died suddenly on May 15 at the age of 37 years, prematurely terminating a brilliant career and depriving the automotive industry of one of its most promising metallurgists and engineers.

Mr. Bissell was born at Milford, Mich., in September, 1892, and had his academic schooling there. He attended Michigan State College, graduating with a degree of Bachelor of Science in 1913. The following year he received a Master of Science degree from the University of Michigan after specializing in thermodynamics. In 1927 an honorary degree in metallurgical engineering was conferred upon him by Michigan State College in recognition of contributions he had made to automotive progress. During the World War he performed valuable services in the physical engineering departments of Dodge Brothers, Inc., Detroit, and the Detroit Steel Products Co. He went with Thompson Products, Inc., 10 years ago as head of the metallurgical department and was made chief engineer last October.

He also directed the activities of a subsidiary company, Thompson Research, Inc., devoted to experimental work with automobile and airplane parts. An exceptionally efficient executive, he left his subordinates in a high state of organization, fully prepared to carry on the work he had planned.

Mr. Bissell became a member of the Society of Automotive Engineers in 1916. A joint paper by him and Gordon T. Williams, on Poppet Exhaust-Valve Design, was read recently before the Buffalo Section of the Society and probably will be published in the July issue of the S. A. E. JOURNAL. He was one of few Americans to be accorded membership in the Royal Aeronautical Society of Great Britain. He is survived by his wife, Genevieve M. (née French) Bissell; his parents, Mr. and Mrs. Nathaniel J. Bissell, of Lansing, Mich., and by two sisters. He had no children.

Osborne Parker Sells

THE MANY personal and business friends of Osborne Parker Sells have learned with regret that on April 16 he passed away at his residence, at Scarsdale, N. Y.

Born in 1870 at Bloomington, Ill., Mr. Sells was educated at the University of Illinois, where he studied mechanical and electrical engineering. His energy and executive ability led to his engagement in various important engineering enterprises, first in the public-service field. Later he built the plant of the Raritan Copper Works, at Perth Amboy, N. J., which ranks prominently among electrolytic copper plants.

In 1913, Mr. Sells became service engineer for the Denver distributor of the Lozier Motor Co. and achieved such gratifying results in adjusting motor-cars to the conditions peculiar to high altitudes that in 1915 the Auto Service Co., of the same city, engaged him as managing engineer. Three years later he received a call from the Double Seal Piston Ring Co. of New York offering him the position of district engineer in the company's business territory east of Pittsburgh, with offices in New York City. He advanced steadily in the organization, occupying the positions of president and sales engineer at the time of his demise.

Mr. Sells attained membership in the Society in 1920, being elected to the grade of Member in September of that year. He was also a member of the Metropolitan Section and of the American Society of Mechanical Engineers.

George H. McDade

MOURNED by his friends and coworkers who had learned to esteem him and to value his work, George H. McDade passed away on April 17 at Toledo, Ohio, in his 65th year.

Born at Ironton, Pa., in July, 1864, and graduated from the public school of that town, Mr. McDade chose to follow the machinist's trade in a day when standardized mass production had not yet risen above the industrial horizon. Fitting himself through home study for ever more exacting work, he was in turn machinist for the Allentown Foundry & Machine Co., machinist and chief inspector of the ordnance shop of the Bethlehem Steel Co., and superintendent of the Philadelphia crane department of the Niles-Bement-Pond Co.

Growth of the motor-car industry brought Mr. McDade into the automotive field in its early days. His connections included some of the best-known firms. He served as assistant superintendent for Everett, Metzger & Flanders; superintendent of the Flint Wagon Works; master mechanic for the Buick Motor Co.; superintendent of the Hudson Motor Car Co., and then of the Northway Motor & Mfg. Co. Six years ago he joined the Willys-Overland Co. as master mechanic.

Mr. McDade joined the Society more than 12 years ago, having been elected to Member grade in April, 1917. He belonged to the Detroit Section.

Applicants Qualified

The following applicants have qualified for admission to the Society between April 10 and May 10, 1929. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

AINSLEY, WALTER G. (A) experimental engineer, Sinclair Refining Co., East Chicago, Ind.; (mail) 2208 West Fifth Avenue, *Gary, Ind.*

ALVEY, JOHN C. (A) chief inspector, Durant Motors of Canada, Ltd., *Leaside, Ont., Canada;* (mail) 60 Donegal Drive.

BAKER, WILLIAM E. (J) draftsman, Ford Motor Co., Dearborn, Mich.; (mail) 4910 Williamson Avenue, *Fordson, Mich.*

BARRETT, DANIEL J., JR. (J) president, general manager, Westchester Airport Corp., *Armonk, N. Y.*

BEDDOE, H. S. (A) managing director, Carr Fastener Co. of Canada, Ltd., Gage Avenue and Beach Road, *Hamilton, Ont., Canada.*

BENNETT, CLAUDE C. (A) secretary, treasurer, A. E. Feragen, Inc., *Seattle, Wash.;* (mail) 3416 19th Avenue, South.

BENNETT, RAYMOND (J) installation layout draftsman, Bragg-Kliesrath Corp., Long Island City, N. Y.; (mail) 436 Bainbridge Street, *Brooklyn, N. Y.*

BERRY, HAROLD P. (M) process and tool engineer, automatic screw-machine products, Victor Talking Machine Co., *Camden, N. J.;* (mail) 2116 North 45th Street.

BORN, FRANK G. (M) chief engineer, The Wahl Co., 1800 Roscoe Street, *Chicago;* (mail) 1436 Addison Street.

BRACKE, ROBERT F. (M) chief engineer, Vacturi Carburetor Co., 1253 Diversey Parkway, *Chicago.*

BRADLEY, CLIFFORD IVES (M) Great Western Tire Co., 2168 East Ninth Street, *Los Angeles.*

BROWN, CLARK H. (J) automotive engineer, The Texas Co., New York City; (mail) 3000 Connecticut Avenue, N. W., Apartment 416, *City of Washington.*

BUDD, ROBERT WILLIS (J) manager of operations, Northland Transportation Co., 509 Sixth Avenue, North, *Minneapolis.*

BUTLER, WILLIAM LAWRENCE (A) vice-president, Cincinnati, Hamilton & Dayton Railway Co., 2011 Franklin Trust Building, *Philadelphia.*

CAIN, DAVID A. (M) lubricating engineer, aviation, Union Oil Co. of California, Room 604, Union Oil Building, Seventh and Hope Streets, *Los Angeles.*

CHAPMAN, GORDON BRADLEY (A) automotive instructor, vocational department Beverly High School, *Beverly, Mass.;* (mail) 93 Baker Avenue.

CHAR, ISAAC (J) gas-engine designer, The Autocar Co., Ardmore, Pa.; (mail) 256 South 60th Street, *Philadelphia.*

CHURCH, HAROLD B. (M) secretary, treasurer, H. B. Church Truck Service Co., 26 Reading Street, *Boston.*

CHUTORASH, GUSTAV (M) assistant to body engineer, Fisher Body Corp., *Detroit;* (mail) 2554 Townsend Avenue.

DEAN, EDWARD E. (M) research engineer, Marvel Carburetor Co., *Flint, Mich.*

DE SAKHNOFFSKY, ALEX (M) art director, Hayes Body Corp., *Grand Rapids, Mich.*

DOWNEY, A. C. (A) general purchasing agent, Chrysler Corp., 341 Massachusetts Avenue, *Detroit.*

DRESSER, WILFRED C. (A) service manager, Capitol Buick Co., Hartford, Conn.; (mail) 551 Burnside Avenue, *Burnside, Conn.*

DUNNING, WILLIAM A. (J) aeronautical drafting, New Standard Aircraft Corp., *Paterson, N. J.;* (mail) 1050 East 24th Street.

EDDY, RAYMOND WILLIAM (J) electrical engineer, Chrysler Corp., Highland Park Plant, Highland Park, Mich.; (mail) 15501 Monte Vista Avenue, *Detroit.*

EDSON, MARMONT (A) sales engineer, The White Co., 225 Broadway, *New York City.*

EDWARDS, E. I. (A) automobile mechanic, Standard Oil Co., *Seattle, Wash.;* (mail) 4546 44th Avenue, S. W.

ELLICOTT, JOSEPH R., JR. (A) representative, Westinghouse Air Brake Co., New York City; (mail) *Grand-View-on-Hudson, N. Y.*

ELLIS, FRANK ALEXANDER (A) service supervisor, Dodge Brothers (Canada) Ltd., *Toronto, Ont., Canada;* (mail) 660 Davenport Road.

EVANS, LLYWELYN CHARLES (J) research engineer, Perfex Corp., Milwaukee; (mail) 917 Grand Avenue, *Racine, Wis.*

FARRINGTON, THEODORE ROBERT (A) instructor in automotive engineering, Board of Education, Chicago; (mail) 2522 West Marquette Road, *Chicago Lawn, Ill.*

FERGUSON, ALEXANDER DALE (M) assistant engineer, bureau of economics, Canadian National Railways, 360 McGill Street, *Montreal, Que., Canada.*

FITZGERALD, T. E. (A) assistant to general sales manager, Mid-Continent Petroleum Corp., *Tulsa, Okla.*

FURST, CLARENCE F. (J) student, Packard Motor Car Co., *Detroit;* (mail) 7204 Kirby, East.

GOODMAN, LOUIS (A) president, Hi Pressure Sales Co., Inc., 1030 Golden Gate Avenue, *San Francisco.*

GORSHKOFF, ALEXIS S. (M) calculating engineer, Gates-Day Aircraft Corp., *Paterson, N. J.;* (mail) 123 Park Avenue.

GRAVES, W. H. (M) chief metallurgist, Packard Motor Car Co., East Grand Boulevard, *Detroit.*

GUYNN, ADAM D. (A) service manager, Rock Island Implement Co., *Kansas City, Mo.;* (mail) 3349 Garfield Avenue.

HARPER, CARL BROWN, LIEUT. (S M) Bureau of Aeronautics, United States Navy, *City of Washington.*

HARTUNG, WALTER M. (J) aeronautical engineer, Skyward Aircraft Co., Brooklyn, N. Y.; (mail) 57 Jefferson Avenue, *Westwood, N. J.*

HARVEY, J. A. (M) operating engineer, Pittsburgh Motor Coach Co., 435 Sixth Avenue, *Pittsburgh.*

HECK, ELMER H. (A) buyer, Chrysler Corp., *Detroit;* (mail) 345 Philip Avenue, North.

HENRY, STEPHEN GARRETT, CAPT. (S M) instructor, infantry (tanks), Motor Transport School, United States Army, *Fort Leonard Wood, Md.*

HERFURTH, WALTER R. (M) assistant traffic manager, Freihofer Baking Co., 20th Street and Indiana Avenue, *Philadelphia.*

HESS, FRED F. (A) president, general manager, Fred Hess Motor Co., *Longview, Wash.*

HIGHT, A. GLEN (A) manager, Mid-West branch, Simplex Piston Ring Co. of America, Inc., Cleveland; (mail) 316 City Bank Building, *Kansas City, Mo.*

HOLMES, E. W. (A) president, general manager, Ernest Holmes Co., 700 East Main Street, *Chattanooga, Tenn.*

HOWARD, CLINTON W., Major (S M) chief, airplane branch, War Department, Air Corps, Materiel Division, Wright Field, *Dayton, Ohio.*

HULBERT, EDWARD A. (J) layout design draftsman, checker, Packard Motor Car Co., Detroit; (mail) 478 Oakridge Avenue, West, *Ferndale, Mich.*

HURRELL, BERTON R. (A) general manager, Willis Jones Machinery Co., Inc., 1601 S. Michigan Avenue, *Chicago.*

JANES, GORDON (M) vice-president, general manager, Canadian S.K.F. Co., Ltd., 1057 Bay Street, *Toronto, Ont., Canada.*

JANEWAY, ROBERT N. (M) consulting engineer, 9028 Dexter Boulevard, *Detroit.*

JENS, ROLAND C. (M) costs engineer, Minneapolis Steel & Machinery Co., 2854 Minnehaha Avenue, *Minneapolis.*

JONES, MALCOLM S. (A) treasurer, Perfect Oil Products Co., Boston; (mail) 53 Brington Road, *Brookline, Mass.*

KERR, WADE H. (A) tool designer, Chrysler Corp., New Castle, Ind.; (mail) *Spiceland, Ind.*

KINNER, W. B. (M) president, Kinner Airplane & Motor Corp., 635 West Colorado, *Glendale, Calif.*

KINSTLER, LEON L. (A) manager, wheel division, Michigan Steel Casting Co., 1986 Guoin Street, *Detroit.*

KLEMM, E. RICHARD, JR. (A) president, experimental engineer, Klemm Automotive Products Co., 1445-55 West Austin Avenue, *Chicago.*

KRUMMEL, FREDERIC CHARLES (M) mechanical engineer, Lowerator Mfg. Co., *Brooklyn, N. Y.;* (mail) 488 Nostrand Avenue.

LAIRD, A. WILSON (M) designer, carrier division, New York Air Brake Co., *Watertown, N. Y.*

LEE, THOMAS (A) general superintendent, Sturges Multiple Battery Corp., *Jamaica, L. I., N. Y.;* (mail) Box 183.

LOCKWOOD, RALPH GREGORY (M) executive engineer, Fairchild Airplane Mfg. Corp., Farmingdale, N. Y.; (mail) 85 Cedar Street, *Amityville, L. I., N. Y.*

MARTIN, LEWIS WILLIAM (A) branch manager, Boston, United Motors Service, Inc., Detroit; (mail) 39 Brighton Avenue, *Boston.*

MCGRAW, FRED V. (A) salesman, Ray Day Piston Co., *Detroit;* (mail) 6659 West Walton.

MCKENNA, DREW (A) eastern sales representative, Cleveland Graphite Bronze Co., Cleveland; (mail) 453 41st Street, *Brooklyn, N. Y.*

MEDVEDEFF, NICHOLAS J. (M) Room 1105, 366 Madison Avenue, *New York City.*

MELLOWES, ALFRED W. (M) vice-president, general manager, National Lock Washer Co., 27 Erie Street, *Milwaukee.*

MENTON, S. (M) production engineer, Chrysler Corp. of Canada, Windsor, Ont., Canada; (mail) 19210 Exeter Avenue, *Detroit.*

MILLER, RAYMOND S. (J) assistant engineer, Scripps Motor Co., *Detroit;* (mail) 5743 Wabash.

MOORE, THOMAS B. (A) president, Detroit Ball Bearing Co., 3958-3960 Cass Avenue, *Detroit.*

MORLEY, HERBERT (M) superintendent of inspection, service engineer, Detroit Gear & Machine Co., 670 East Woodbridge Street, *Detroit.*

MYERS, OAK MAJOR (A) manager, owner, Myers Motor Co., 36th Avenue, S. W., and Fauntleroy Avenue, *Seattle.*

NEVIN, WILLIAM M. (A) secretary, Nevin Bus Lines, Inc., 203 West 33rd Street, *New York City,*

OBER, ROY (J) draftsman, International Harvester Co., *Springfield, Ohio;* (mail) Rural route No. 6.

OGATA, TAKIYOSHI (M) inspector for aviation, Office of Japanese Military Inspector, 1775 Broadway, *New York City.*

OTTO, BOWMAN R. (J) prospect engineer, Curtiss Aeroplane & Motor Corp., *Buffalo;* (mail) 140 East Utica Street.

PATON, ROY W. (M) experimental engineer, Perfect Circle Co., *Hagerstown, Ind.;* (mail) 204 Sycamore.

PERRY, RAYMOND S. (M) production manager, Hudson Motor Car Co., 12601 East Jefferson Avenue, *Detroit.*

PETERSON, HAROLD C. (M) chief engineer, Bundy Tubing Co., *Detroit;* (mail) 3310 Rochester Avenue.

PIERCE, PAUL P. (M) engineer, Bragg-Kliesrath Corp., Long Island City, N. Y.; (mail) 2 Livingston Avenue, *White Plains, N. Y.*

PLUMLEY, BURTON J. (A) sales engineer, Aluminum Industries, Inc., 718 Fisher Building, *Detroit.*

QUIGLEY, JOHN MILTON (J) draftsman, designer, Marion Motors, Inc., *Marion, Ohio;* (mail) 589 Olney Avenue.

REASON, EUGENE L. (A) assistant general purchasing agent, Chrysler Corp., *Detroit.*

RETZLAFF, W. G. (M) factory manager, Fruehauf Trailer Co., *Detroit.*

ROCKWELL, HUGH M. (M) owner, 1841 Broadway, *New York City.*

ROCKWELL, WALTER FRANCIS (M) vice-president, general manager, Wisconsin Axle Co., 567 High Street, *Oshkosh, Wis.*

RONNING, ADOLPH (M) president, treasurer, engineer, Ronning Machinery Co., Minneapolis; director, vice-president, Patents Holding Corp., Frederick, Md.; (mail) 3027 47th Avenue, South, *Minneapolis.*

RUDOLPH, SAMUEL W. (M) service manager, Harper & Harper, *Philadelphia;* (mail) 4623 Spruce Street.

RUSSELL, C. B. (A) manager, Detroit office, Victor Mfg. & Gasket Co., Chicago; (mail) 4-121 General Motors Building, *Detroit.*

SAY, F. M. (A) mechanic, Universal Airline Systems, Inc., *Chicago;* (mail) 6314 South Troy Street.

SCHAEFER, ROBERT M. (J) draftsman, Waukesha Motor Co., *Waukesha, Wis.;* (mail) 121 Wright Street.

SCHREIBER, MARTIN (M) general manager, in charge of plant, Public Service Coordinated Transport, Public Service Interstate Transportation Co., 80 Park Place, *Newark, N. J.*

SEMENYNA, WALDIMIR (J) designing, Gates Day Aircraft Corp., *Paterson, N. J.;* (mail) 431 Broadway.

SHAFER, R. V. (A) service manager, Harnischfeger Sales Corp., 32 Beale Street, *San Francisco.*

SMITH, K. D. (M) manager, tire construction, design, B. F. Goodrich Rubber Co., *Akron, Ohio.*

SMITS, RAYMOND R. (M) body engineer, Sayers & Scoville, 2100 Gest Street, *Cincinnati.*

SPRUNG, OREN C. (J) draftsman, Handy Governor Corp., *Detroit;* (mail) 1920 Scotten Avenue.

STEINER, HUBBARD W. (M) United States Rubber Co., 6670 Jefferson Avenue, East, *Detroit.*

STEPHENS, F. A. (A) dynamometer operator, Studebaker Corp., *South Bend, Ind.;* (mail) 506 East Ohio Street.

STREYFFERT, M. J. (M) assistant factory superintendent, Willys-Overland, Ltd., Toronto; (mail) 745 Bloor Street, West, Apartment 8, *Toronto 4, Ont., Canada.*

TEETOR, DON H. (A) assistant sales manager, Perfect Circle Co., *Hagerstown, Ind.*

VAN DENBURG, CARROLL H. (A) president, treasurer, Van Denburg Co., Inc., 741-745 West Genesee Street, *Syracuse.*

VON STORP, HANS A. (A) designer, engineering department, Hupp Motor Car Corp., *Detroit;* (mail) 2628 Hogarth.

WADDELL, HAROLD F. (J) shop foreman, Gasey Bowyer, Inc., *Seattle, Wash.;* (mail) 7134 32nd Avenue, S. W.

WALTERS, H. C. (M) designer, Delco Products Corp., *Dayton, Ohio;* (mail) 550 Forest Avenue, Apartment 19.

WARNER, ARTHUR T. (M) general manager, in charge of traffic, Public Service Coordinated Transport, 80 Park Place, *Newark, N. J.*

WEINGARDEN, NATHAN (J) assistant chief draftsman, chassis division, Oakland Motor Car Co., Pontiac, Mich.; (mail) 3030 Blaine Avenue, *Detroit.*

WESTCOTT, THOMAS S. (M) garage superintendent, Toronto Transportation Commission, *Toronto, Ont., Canada;* (mail) 94 Wolverleight Boulevard.

WHIT, LAWRENCE B. (J) Hotel Bretton Hall, 2350 Broadway, *New York City.*

WYCKOFF, WILLIAM HENRY (J) design layout, checking, automotive and electrical, Noble & Harris, *Detroit;* (mail) 835 Gladstone.

ZUFALL, EARL T. (A) bus mechanic, Interstate Public Service Co., Indianapolis; (mail) 335 East 14th Street, *New Albany, Ind.*

Aeronautic Engineering

(*Concluded from page* 664)

Norma-Hoffmann Bearings Corporation, Vice-Chairman; F. H. Buhlmann, Rollway Bearing Co.; E. R. Carter, Jr., Fafnir Bearing Co.; D. F. Chambers, the Bearings Co. of America; L. A. Cummings, Marlin-Rockwell Corp.; T. C. Delaval-Crow, New Departure Mfg. Co.; H. R. Gibbons, Hyatt Roller Bearings Division, General Motors Corp.; H. N. Parsons, Strom Bearings Co.; and R. S. Burnett, manager Standards Department, S.A.E. The guests attending were Thomas Barish, Marlin-Rockwell Corp.; J. R. Cautley, Bendix Brake Co.; F. W. Gurney, Marlin-Rockwell Corp.; R. M. Riblet, Timken Roller Bearing Co.; and J. S. Tawresey, S. K. F. Industries, Inc.

Applicants for Membership

The applications for membership received between April 15 and May 15, 1929, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ADAMS, CLARK M., vice-president and assistant general manager, Nagel Electric Co., *Toledo, Ohio.*

ALDRICH, ROBERT, president, Flyers, Inc., *Albany, N. Y.*

ALLISON, JOHN M., JR., assistant aeronautical engineer, United States Naval Air Station, *Lakehurst, N. J.*

ANGELL, CHESTER M., vice-president, Vesta Battery Corp., *Chicago.*

ANDERSON, PAUL A., assistant airplane engineer, Wright Aeronautical Corp., *Paterson, N. J.*

AYERS, H. P., private pilot, *Longuevil, Que., Canada.*

BAINE, JOHN CHALMERS, JR., engineer, rolling stock and shops department, New Orleans Public Service, Inc., *New Orleans.*

BARROW, BENJAMIN EUTOIS, engineer, Heywood Starter Corp., *Detroit.*

BAYES, WILLIAM, time-study chief, White Motor Co., *Cleveland.*

BERGEY, MILTON D., president, Campbell-Ewald, Ltd., *Toronto 2, Ont., Canada.*

BERING, DONALD A., automotive department, Shell Oil Co., *San Francisco.*

BLOOD, ARTHUR R., designing, H. H. Franklin Mfg. Co., *Syracuse.*

BLYTHE, GERARD STUART, sales engineer, sales engineering and service department, Tide Water Oil Co., *New York City.*

BOONE, ANDREW RICHMOND, writer on aeronautical subjects, 613 Spreckels Theatre Building, *San Diego, Calif.*

BOUCHARD, EDWARD E., salesman, Ford Motor Co., *New York City.*

BROOKS, FREDERICK A., chief engineer, Metropolitan Development Syndicate, *Hollywood, Calif.*

BROWN, GORDON D., material supervisor, Douglas Aircraft Co., *Santa Monica, Calif.*

BROWN, LOUIS L., carburetion engineer, stock superintendent, Zenith Carburetor Agency, *Los Angeles.*

CLARK, CHARLES M., service representative, Reo Motor Car Co., *Detroit.*

CLEAVER, BENJAMIN JAMES, project engineer, General Motors Truck Co., *Detroit.*

CLELAND, JAMES LEIPER, department head (automotive) Hamilton Technical Institute, *Hamilton, Ont., Canada.*

CLEVELAND, E. W., transport pilot, salesman, trouble man, Cleveland Pneumatic Tool Co., *Cleveland.*

COLEMAN, ALFRED F., manager, Standard Oil Co. of New York, *New York City.*

DORR, GEORGE NICKOLI, chief mechanical engineer, Metalwood Mfg. Co., *Detroit.*

DOYLE, ARMAND JAY, sales engineer, Sinclair Refining Co., *Chicago.*

EMERY, JOHN C., motor transport editor, *Railway Age*, Simmons Boardman Publishing Co., *Chicago.*

FARNSWORTH, CHARLES CLARK, draftsman, Fokker Aircraft Corp., *Glendale, W. Va.*

FARREL-BIRMINGHAM CO., INC., *Buffalo.*

FLANARY, C. A., service manager, J. F. Hickey Motor Car Co., *Tacoma, Wash.*

FOLLETT, W. H., foreman, motor equipment transportation, Paine Lubricating Co., *Oshkosh, Wis.*

FOOTE, E. T., vice-president, Union Battery Co., *Chicago.*

FRIES, WALTER C., production manager and secretary, Ahlberg Bearing Co. of California, Inc., *Los Angeles.*

GARNER, F. H., chief chemist, Anglo-American Oil Co., Ltd., *London, S. W. 1, England.*

GRAVES, BERT, director of purchases, White Motor Co., *Cleveland.*

HAAS, JOSEPH P., draftsman, American Car & Foundry Co., Hall-Scott Division, *Berkeley, Calif.*

HANCOCK, CHESTER A., manager, Hancock Auto Repair, *Seattle, Wash.*

HARDECKER, JOHN F., chief draftsman, United States Naval Aircraft Factory, Navy Yard, *Philadelphia.*

HARDESTY, B. F., president, Refined Steel Co., *Pittsburgh.*

HARRIS, JAMES L., branch manager, Mack International Motor Truck Co., *Omaha, Neb.*

HAYNES, O. B., proprietor and machinist, Haynes Repair Shop, *Wenatchee, Wash.*

HAZEN, GEORGE W., maintenance manager, Uppercu Cadillac Corp., *Yonkers, N. Y.*

HEATH, SOPHIE MARY, aeronautical advisor's test pilot, American Cirrus Engine Co., *Belleville, N. J.*

HILL, BENNETT, engineer, aviation motor department, Horace E. Dodge Boat Works, *Detroit.*

HISS, RICHARD E., draftsman, Heywood Starter Corp., *Detroit.*

HODAPP, GEORGE H., assistant general manager, Penn Spring Works, Inc., *Baldwinville, N. Y.*

HOFFMAN, CHRIST, draftsman, Stewart Motor Corp., *Buffalo.*

HOUSTON, HERBERT W., shop superintendent, experimental and research laboratory, Hughes Tool Co., *Los Angeles.*

HURD, LELAND C., FIRST LIEUTENANT, Air Corps, U. S. A., City of Washington.

IYENGAR, V., VENUSAWMY, assistant superintendent, motor section, Government industrial Institute, *Madura, South India.*

JUDGE, FRANCIS H., district manager, Western Felt Works, *Cleveland.*

KALCHTHALER, CARL W., sales engineer, Hyatt Roller Bearing Co., *Detroit.*

KENYON, B. H., superintendent, Providence Base Works of General Electric Co., *Providence, R. I.*

KNACK, FREDERICK, secretary, Aerotech, Inc., *Moline, Ill.*

KNAUSS, W. G., district service manager, The White Co., *Newark, N. J.*

KNOLL, FELIX W. A., vice-president and chief engineer, Knoll Aircraft Corp., *Wichita, Kan.*

KURTZE, A. HARRY, machine designer, A. O. Smith Corp., *Milwaukee.*

LANDERS, SAMUEL P., general manager, New York branch, General Motors Truck Co., *New York City.*

LANGE, G. M., service department, Timken Roller Bearing Co., *Canton, Ohio.*

LARKIN, ANTHONY J., service engineer, Heywood Starter Corp., *Detroit.*

LINDEN, DONALD S., salesmanager, lubricant department, R. M. Hellingshead Co., Ltd., *Toronto, Ont., Canada.*

LONG, MATHEW RAYMOND, shop foreman, Swanson & Shomar, *Port Angeles, Wash.*

LOUNSBURY, J. E., research engineer, General Motors Corp., *Detroit.*

LYDECKER, KENNETH, sales engineer, The White Co., *New York City.*

MARTIN, CHARLES G., Heywood Starter Corp., *Detroit.*

NYBERG, GEORGE E., service superintendent, Lamping Motor Co., *Seattle, Wash.*

OBERLE, FRANZ, field representative, Robert Bosch Magneto Co., Inc., *Long Island City, N. Y.*

OGDEN, A. B., superintendent of equipment, Union Pacific Stages Co., *Portland, Ore.*

OLIVER, CHRISTOPHER SIBLEY, works manager, Humber, Ltd., *Coventry, England.*

PAGE, EDWIN R., assistant chief powerplant branch, United States Army Air Corps, Wright Field, *Dayton, Ohio.*

PARKER, FRED W., JR., sales engineering, Timken-Detroit Axle Co., *Detroit.*

RAINVILLE, WALTER STEWART, equipment engineer, rolling stock and shops department, New Orleans Public Service, Inc., *New Orleans.*

ROBINSON, DAYTON H., representative, Westinghouse Air Brake Co., *Wilmerding, Pa.*

SANDER, J. W., planning department, Fokker Aircraft Corp. of America, *Glendale, W. Va.*

SCHROEDER, CARL A. P., draftsman, Timken-Detroit Axle Co., *Detroit.*

SEECK, FERDINAND W., president, Seeck Differential Co., *Lebanon, Ore.*

SILVERMAN, I., chief chemist, L. Sonneborn Sons, Belleville Works, *Belleville, N. J.*

STACKPOLE CARBON CO., *St. Marys, Pa.*

STEENECK, ROBERT F., western representative, shackle division, Fafnir Bearing Co., *New Britain, Conn.*

STILLMAN, HARRY M., branch manager, North East Electric Co., *Detroit.*

STOVER, FRANK B., general manager and secretary, Heywood Starter Corp., *Detroit.*

SUGIMOTO, OSAMU, engineer, lieutenant commander, Imperial Japanese Navy, *New York City.*

SULLIVAN, WILLIAM P., president and general manager, Sullivan Aircraft Corp., *Wichita, Kan.*

TEICHERT, CONRAD A., engineer, Indian Motorcycle Co., *Springfield, Mass.*

THOMPSON, HENRY H., general engineer in aviation activities, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

THOMPSON, J. ARTHUR, president, Gladacres, Inc., *Rushville, Ill.*

TOMIK, GEORGE A., designing engineer, International Harvester Co., *Chicago.*

TOWNHILL, ARTHUR, research engineer, Lycoming Mfg. Co., *Wuliamsport, Pa.*

VAILLANCOURT, JEREMIE ALEXANDRE, body engineer, M. P. Moller Motor Car Co., *Hagerstown, Md.*

VERESKY, LOUIS H., president and general manager, Euclid Wood Products Co., *Cleveland.*

VILLEMIN, MAURICE, service field representative, General Motors Near East S. A., *Alexandria, Egypt.*

VOORHEES, ELGIE P., operator, Los Angeles Motor Coach Co., *Los Angeles.*

VORHAUER, H. G., engineer, Pacific Technical University, Inc., *San Diego, Calif.*

VULTEE, GERARD F., chief engineer, Lockheed Aircraft Co., *Burbank, Calif.*

WHITNEY, GEORGE W., metallurgist, Bliss & Laughlin, Inc., *Harvey, Ill.*

WICK, OSCAR, president, C. W. S. Grinding & Machine Works, *Portland, Ore.*

WILCOX, MILTON SEABURY, supervisor of traffic, New York Edison Co., *New York City.*

WILLIAMSON, R. J., general superintendent, Trimont Mfg. Co., *Roxbury, Mass.*

WILSON, HOBERT LADOYT, project engineer, materiel division, Wright Field, *Dayton, Ohio.*

WOOD, L. P., general sales manager, Crown-Dominion Oil Co., Ltd., *Hamilton, Ont., Canada.*

WOODS, SYLVAN, chief of engineering division, Craveroiler Co. of America, *Philadelphia.*

WYER, GEORGE R., manager, engine department, Canadian Fairbanks-Morse Co., Ltd., *West Toronto, Ont., Canada.*

WYSOR, HENRY, metallurgical engineer, Bethlehem Steel Co., *Bethlehem, Pa.*

YOUNG, ARTHUR E., director of service, consulting engineer, Societa Anonima Fiat, *Torino, Italy.*

Notes and Reviews

AIRCRAFT

Full-Scale Tests of Wood Propellers on a VE-7 Airplane in the Propeller Research Tunnel. Report No. 301. By Fred E. Weick. Published by the National Advisory Committee for Aeronautics, City of Washington; 23 pp., illustrated. [A-1]

The investigation described in this report was made primarily to afford a comparison between propeller tests in the new Propeller-Research Tunnel and flight tests and small-model tests on propellers. Three wood propellers which had previously been tested in flight on a VE-7 airplane, and of which models had also been tested in a wind-tunnel, were tested again on a VE-7 airplane in the new tunnel. The results of the last-named tests are in fair agreement with those of the flight and model tests.

Tests were also made with the tail surfaces removed and with both the wings and tail surfaces removed. It was found that the effect of the tail surfaces on the propeller characteristics was negligible but that the wings reduced the maximum propulsive efficiency about 5 per cent.

An Investigation of the Use of Discharge Valves and an Intake Control for Improving the Performance of N.A.C.A. Roots-Type Supercharger. Report No. 303. By Oscar W. Schey and Ernest E. Wilson. Published by the National Advisory Committee for Aeronautics, City of Washington; 9 pp., illustrated. [A-1]

This report presents the results of an analytical investigation on the practicability of using mechanically operated discharge valves in conjunction with a manually operated intake control for improving the performance of N.A.C.A. Roots-type superchargers. The investigation was conducted by the staff of the National Advisory Committee for Aeronautics at Langley Field, Va.

These valves, which may be of either the oscillating or rotating type, are placed in the discharge opening of the supercharger and are so shaped and synchronized with the supercharger impellers that they do not open until the air has been compressed to the delivery pressure. The intake control limits the quantity of air compressed to engine requirements by permitting the excess air to escape from the compression chamber before compression begins.

The percentage of power saving and the actual horsepower saved were computed for altitudes from 0 to 20,000 ft. These computations are based on the pressure-volume cards for the conventional and the modified Roots-type superchargers and on the results of laboratory tests of the conventional type.

The use of discharge valves shows a power saving of approximately 26 per cent at a critical altitude of 20,000 ft. In addition, these valves reduce the amplitude of the discharge pulsations and increase the volumetric efficiency. With slow-speed Roots blowers operating at high-pressure differences even better results would be expected. For aircraft-engine superchargers operating at high speeds, these discharge valves increase the performance as stated but have the disadvantages of increasing the weight and adding a high-speed mechanism to a simple machine.

An Investigation of the Aerodynamic Characteristics of an Airplane Equipped with Several Different Sets of Wings. Report No. 304. By J. W. Crowley, Jr., and M. W. Green. Published by the National Advisory Committee for Aeronautics, City of Washington; 13 pp., illustrated. [A-1]

This investigation was conducted at the request of the Army Air Corps for the purpose of comparing the full-scale lift and drag characteristics of an airplane equipped with several sets of wings of commonly used airfoil-sections. A Sperry Messenger airplane with wings of R.A.F.-15, U.S.A.-5, U.S.A.-27, and Göttingen-387 airfoil-sections was flown and the lift and drag characteristics of the airplane with each set of wings were determined by means of glide tests.

The results are presented in tabular and curve form.

Landing and Braking of Airplanes. By Louis Breguet. Technical Memorandum No. 507. Translated from supplements to Nos. 8 and 9, 1928, of La Chronique des Avions Breguet by the National Advisory Committee for Aeronautics, City of Washington; 28 pp., 8 figures. [A-1]

Various devices have been proposed for overcoming the difficulties and dangers attendant upon the making of a forced landing on a field more or less unsuitable as to smoothness, size and orientation. These the author predicts will eventually disappear of themselves with a suitable distribution of the engine-propeller groups. In this connection he points out that the airplanes with lifting propellers for taking off and landing vertically have poor aerodynamic qualities and are exposed to very great danger if their lifting propellers stop or fail to function properly.

The problem has been approached from another angle by attempting to reduce the minimum flight-speed, which is regarded as the practical landing-speed. This author treats other elements, such as the angle of glide and the shortening of the landing run by air and ground brakes, which also have an important bearing on the safety of landing.

Aeromechanical Experimentation. By R. Katzmayr. Technical Memorandum No. 508. Translated from *Luftflotten*, 1928, by the National Advisory Committee for Aeronautics, City of Washington; 16 pp., 7 figures. [A-1]

This treatise on wind-tunnel tests was written in an endeavor to show that aeromechanical experimentation has become an important aid to theory and constitutes a science in itself. The types of test developed in various countries are briefly reviewed and the paper as a whole may be regarded as an argument in favor of providing means for similar work in Austria.

Theoretical Investigation of the Effect of the Ailerons on the Wing of an Airplane. By C. Wieselsberger. Technical Memorandum No. 510. Translated from a Report of the Aeronautical Research Institute, Tokyo Imperial University, no. 30, vol. II, 16,

(*Continued on next left-hand page*)

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motor-coach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

JUN 3 1929

S·A·E JOURNAL

VOL. XXIV No. 6

JUNE 1929

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
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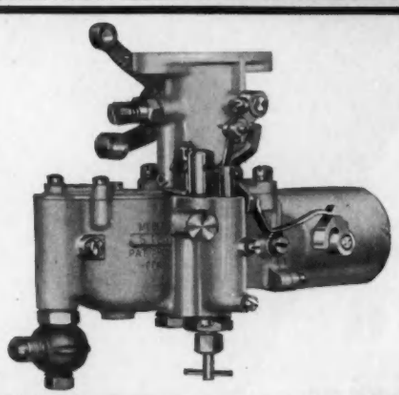

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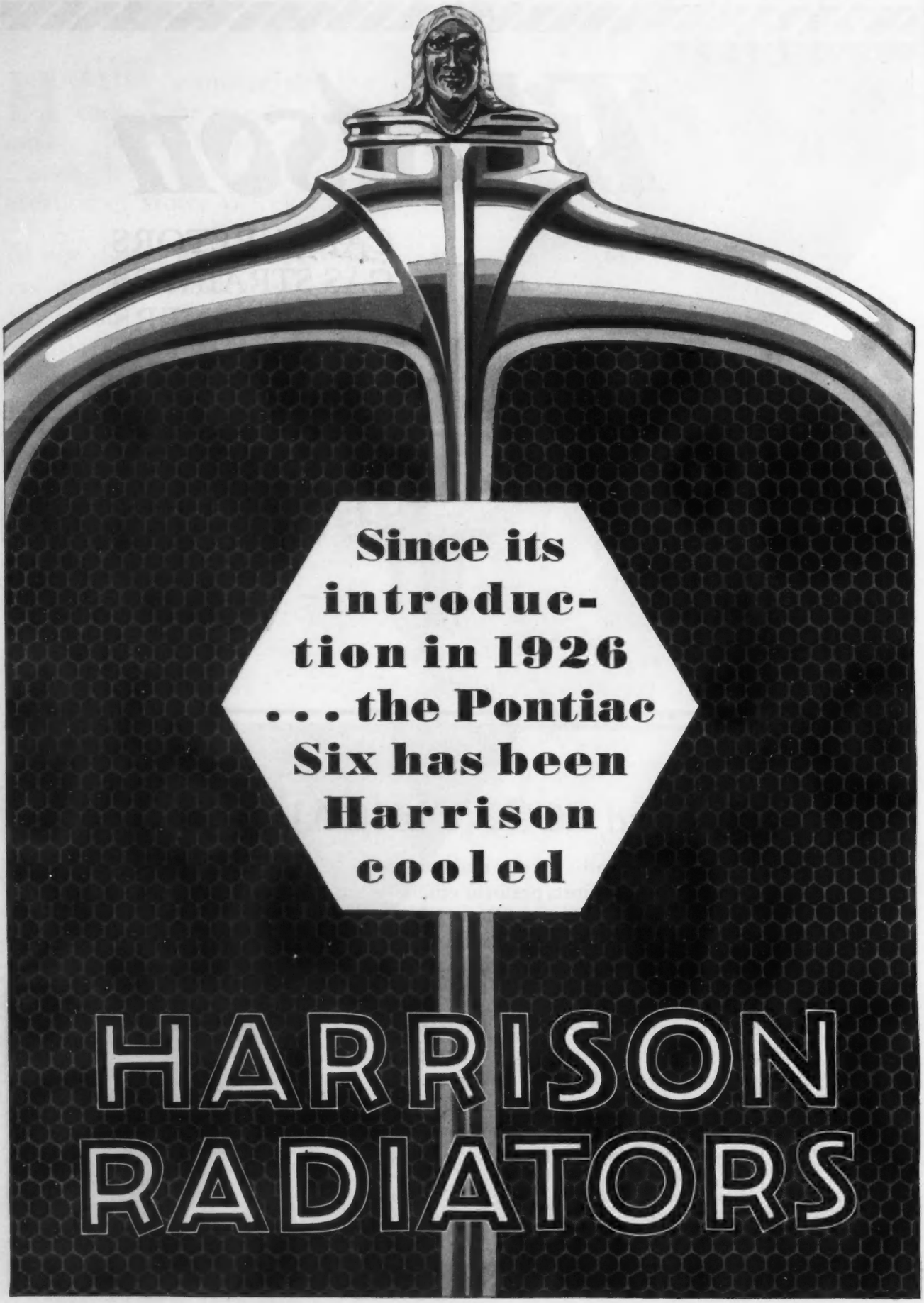
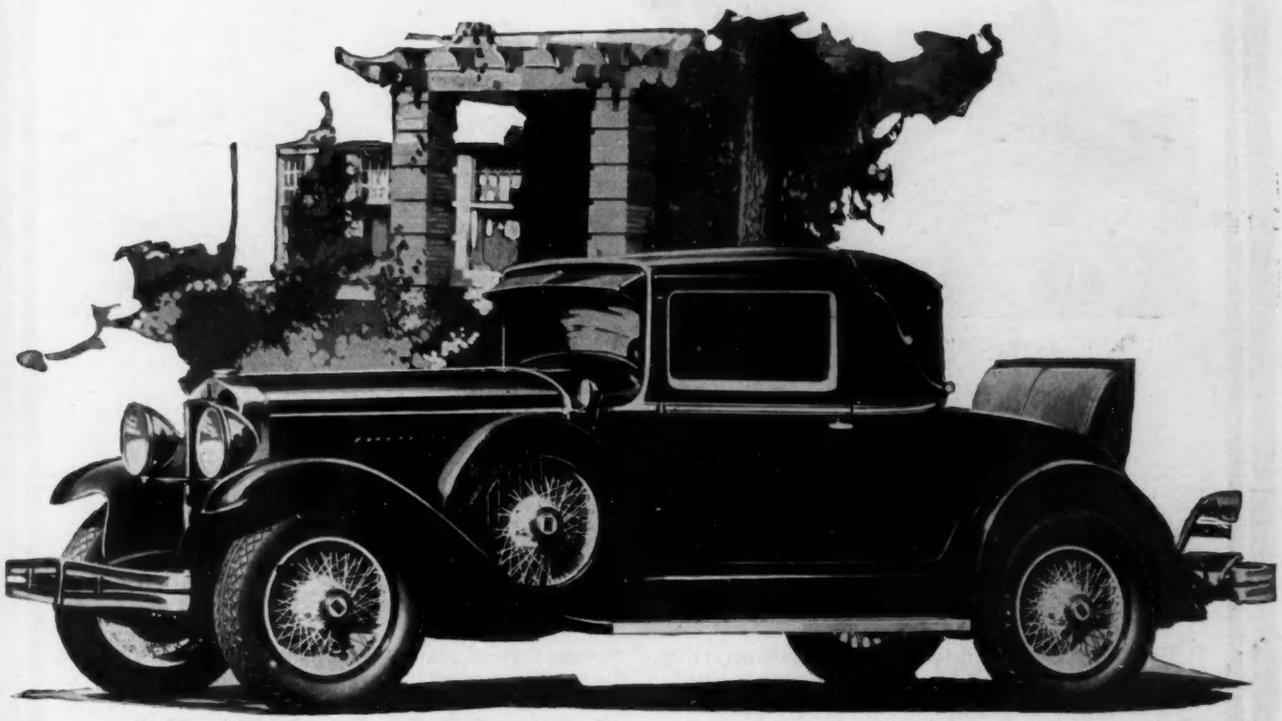

Since its introduction in 1926 . . . the Pontiac Six has been Harrison cooled
HARRISON
RADIATORS

Hupmobiles and Hyatts



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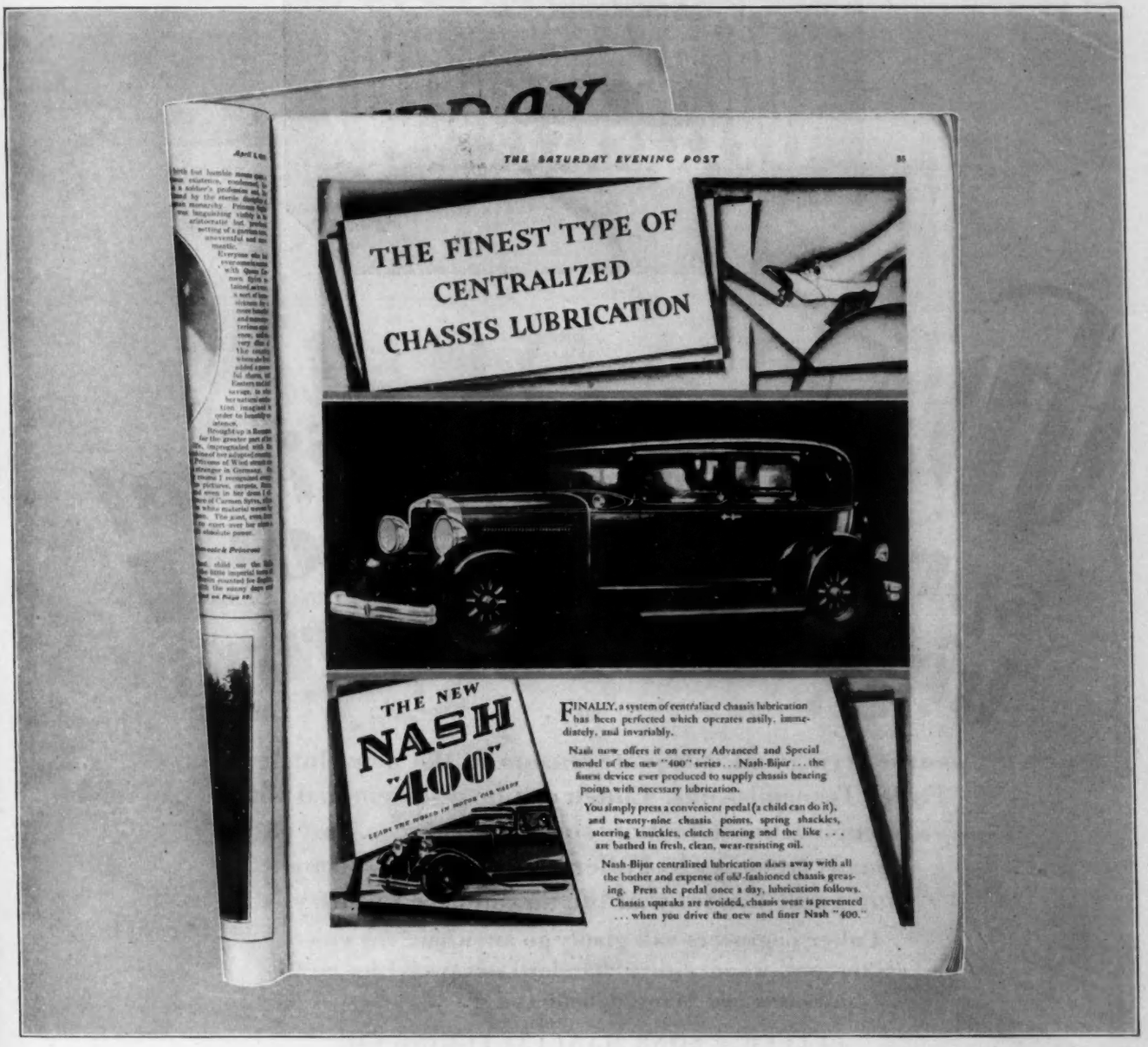
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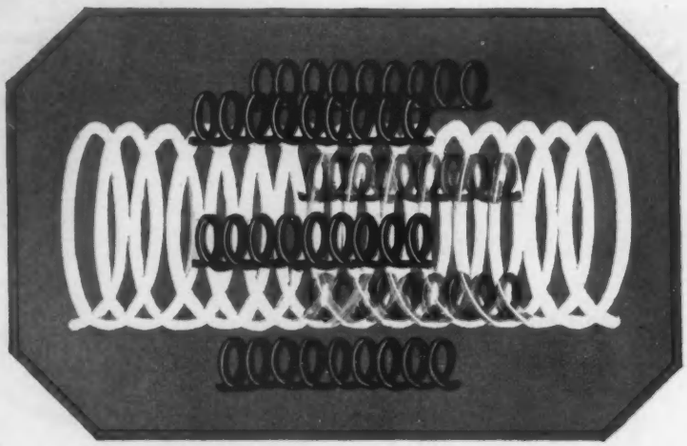

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assure permanent, adequate tension in the new clutch for Fuller Transmissions. Clutch can be disassembled with a wrench without bucking spring pressure... Just one of many reasons why Fuller Transmissions are making great headway in the automotive industry.

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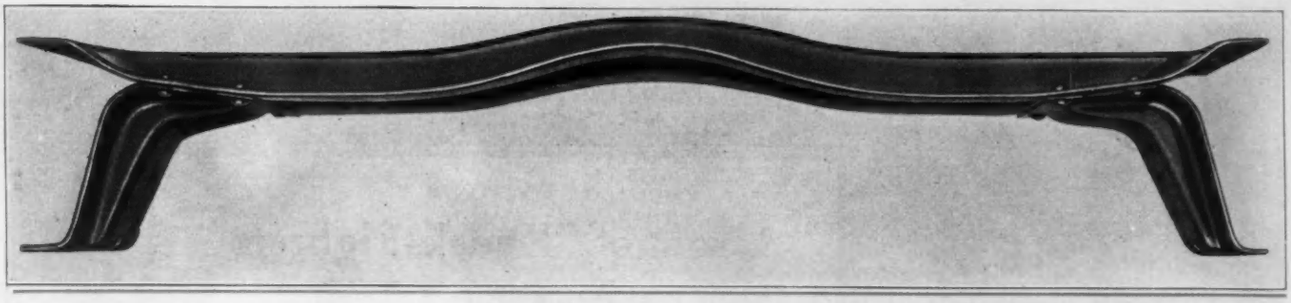

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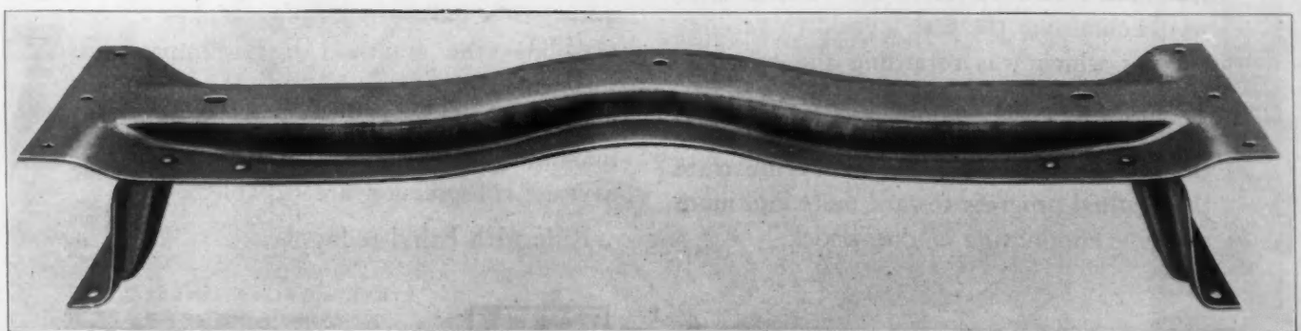
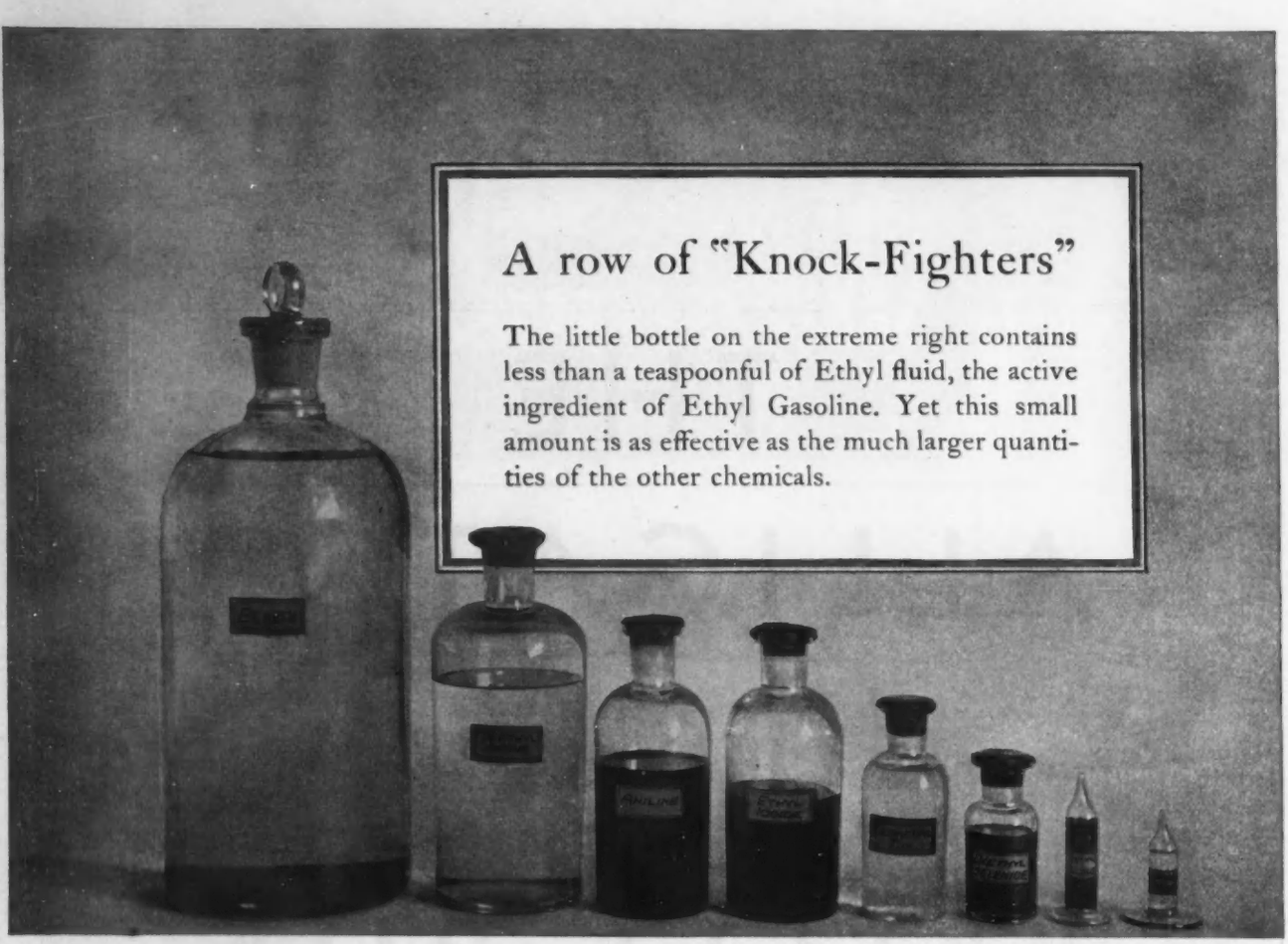


SMITHSTEEL FRAMES


A row of "Knock-Fighters"
The little bottle on the extreme right contains less than a teaspoonful of Ethyl fluid, the active ingredient of Ethyl Gasoline. Yet this small amount is as effective as the much larger quantities of the other chemicals.

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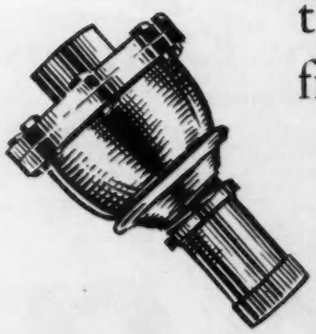

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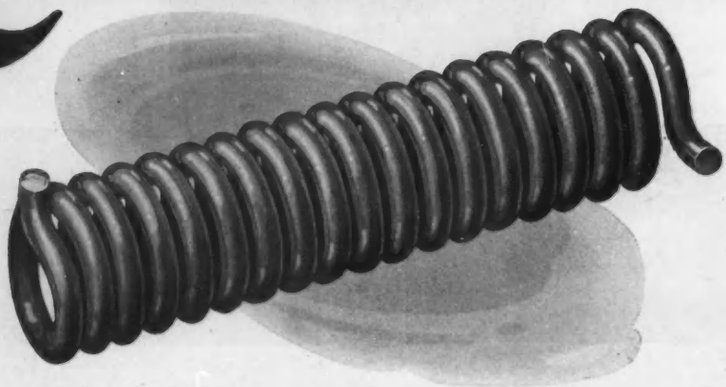

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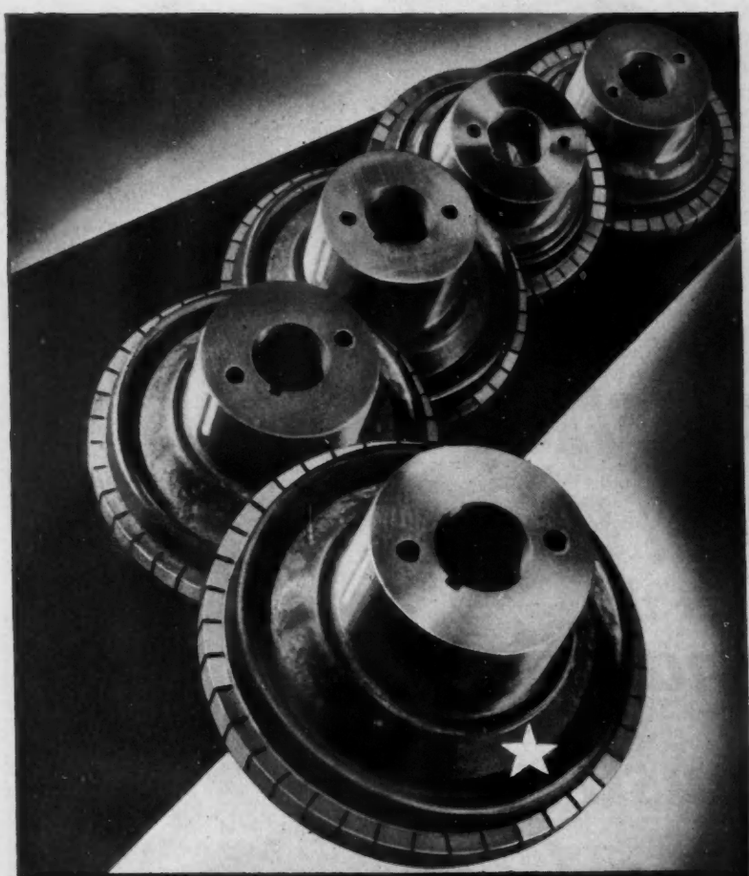

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THE Wagner Electric Corporation makes motors. *Quality* motors. They make fans, too. *Quality* fans. And transformers. *Quality* transformers. A house whose reputation is unquestioned, they demand the best, and they get it. . . . See the commutator on the right? The section with the star? Made of Durez.

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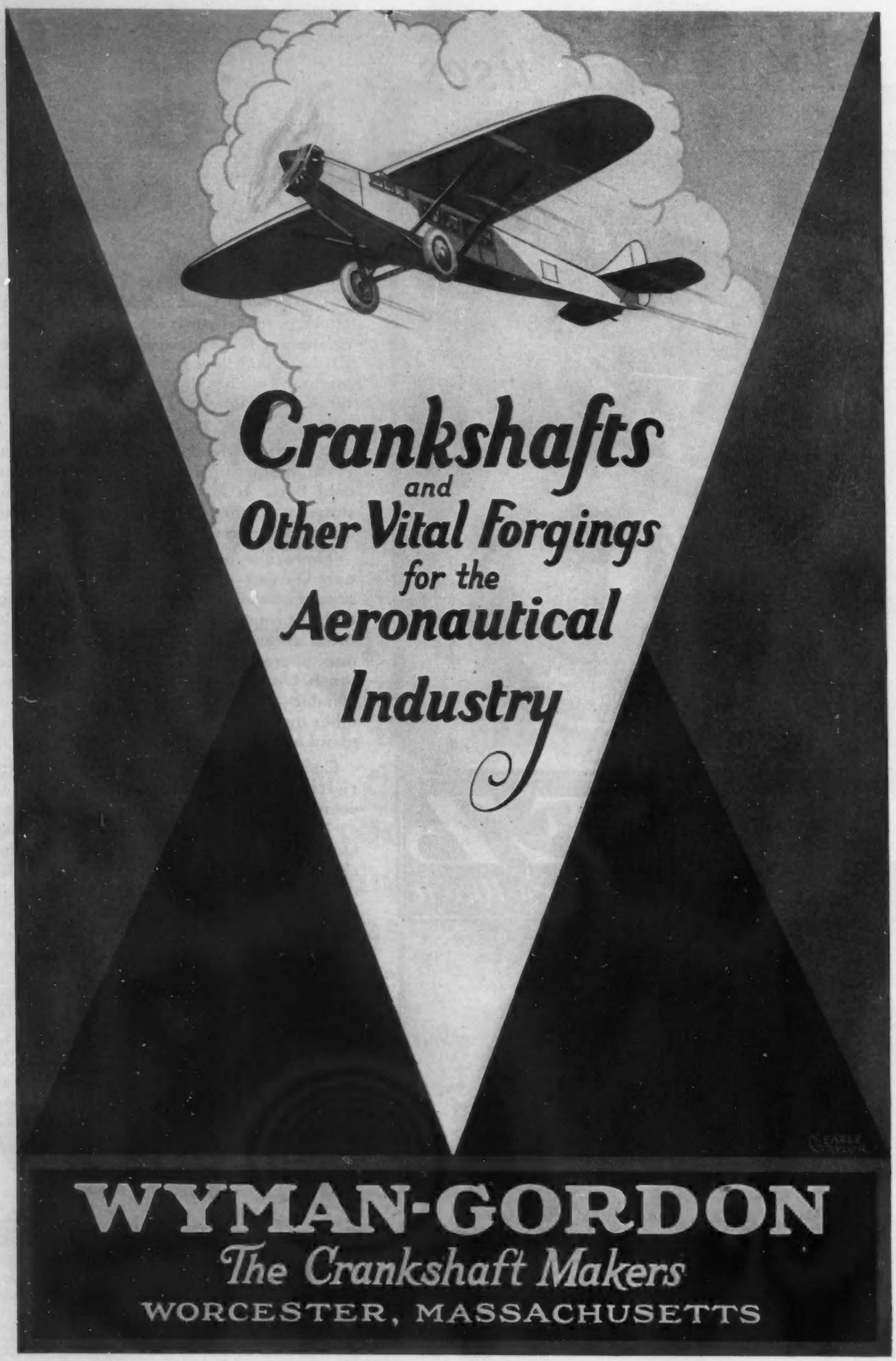
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Other Vital Forgings
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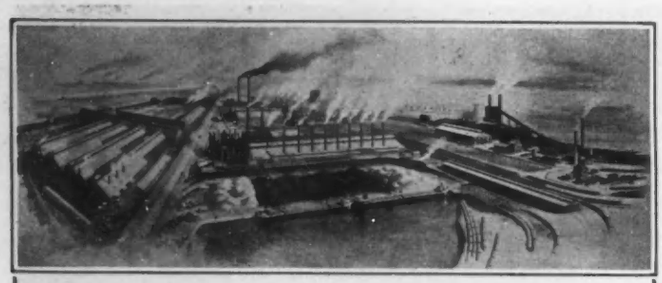

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Notes and Reviews

Continued

December, 1927, by the National Advisory Committee for Aeronautics, City of Washington; 25 pp., 4 figures. [A-1]

The effect of the ailerons is quantitatively investigated on the basis of Prandtl's wing theory. In Part I a simple rectangular wing is assumed, the angle of attack of which, corresponding to the aileron deflection, is increased at one end and decreased by a like amount at the other end of the wing. According to the author, the distribution of the circulation can be expressed by a Fourier series, the coefficients of which are determined from a system of linear equations. The distribution is calculated for different aileron lengths. The rolling moment, the additional induced drag and the yawing moment can all be determined from the distribution. In Part II the relations are investigated for the case in which both ailerons are deflected in the same direction, and the lift and induced drag are calculated for different aileron lengths.

Condensed Data on the Aircraft Engines of the World. Technical Note No. 303. Compiled by C. S. Fliedner. Published by the National Advisory Committee for Aeronautics, City of Washington; 15 pp. [A-1]

This compilation of the outstanding characteristics of the available aircraft engines of the world has been prepared as a compact ready reference for desk use. It gives a skeleton outline of the characteristics of engines reported in the technical press as being in either the experimental, development or production stage. The name, maker, type of design, bore and stroke, horsepower rating, revolutions per minute, number of cylinders, cooling, cylinder arrangement, compression ratio, over-all diameter, and weight are given in the table, with a column for miscellaneous remarks.

New engines are being given acceptance tests every week by the Department of Commerce. A current list of engines approved for aircraft can be procured directly from the Aeronautics Branch, Department of Commerce, City of Washington.

Aeronautical Design Seen at the Detroit Show. Published in *American Machinist*, April 25, 1929, p. 671. [A-1]

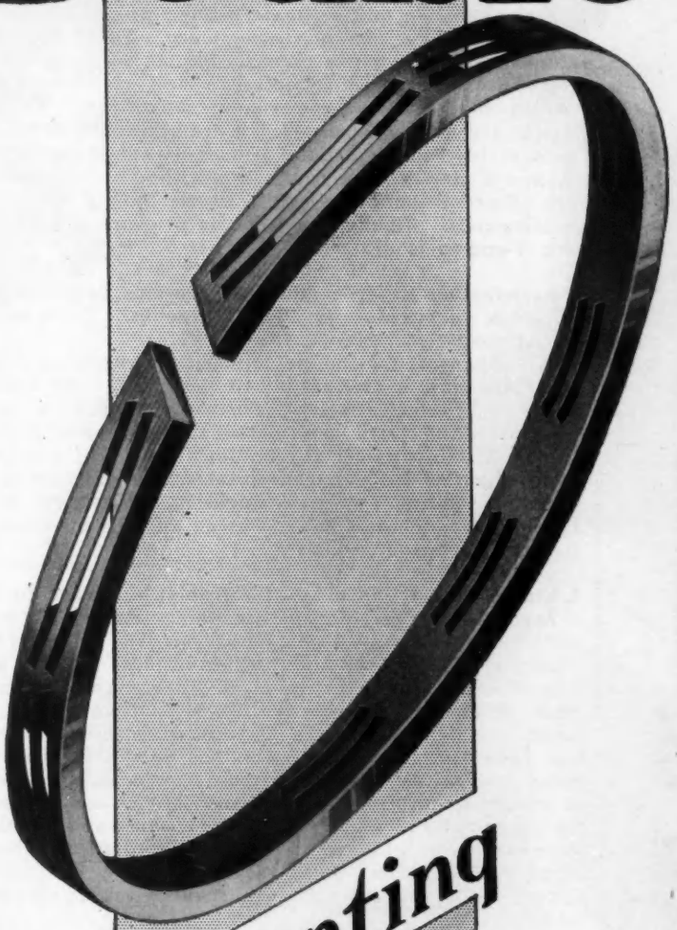
In covering the features of the second All-American Aircraft Show, held in Detroit during the week of April 6 to 13, the author of this article brings out some significant points regarding the value of the show from an engineering viewpoint. Foremost he mentions the opportunity to study more than 100 airplane designs and also the details of a large number of engines and accessories, giving an accurate picture of the status of aeronautic engineering. He points out that when a large number of airplanes are displayed it is possible to note the general design tendencies and to visualize the airplane of the future. A noticeable tendency in comparing this year's show with that of last year is the attempt to simplify designs and mechanisms with the idea of high quantity production. N. A. C. A. low-drag radial-engine cowling has been adapted to airplanes, tapered wings are in more general use, and metal wing-structures are in evidence. These and a number of special design-features exhibited at the show are discussed in the text and abundantly illustrated.

Beitrag zur Triebwerksberechnung von Flugmotoren. By O. Steigenberger. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, March 14, 1929, p. 113. [A-1]

Of great importance in the design of aircraft engines is the proper dimensioning of the bearing surface. For the design of automobile engines, for the most part only the maximum pressure due to combustion and the reciprocating and rotating parts need be determined. A proper consideration of aircraft power-plants requires in addition knowl-

(*Continued on next left-hand page*)

Double Slot



Up Slanting Of Course

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THE principle of the Double Slot Drainoil is exactly the same as the famous Drainoil but the action is increased by an additional row of slots.

To present day high speed engines and to badly worn cylinders with especially difficult oil problems, Double Slot Drainoil gives oil relief plus sufficient lubrication.

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The Piston Ring Company

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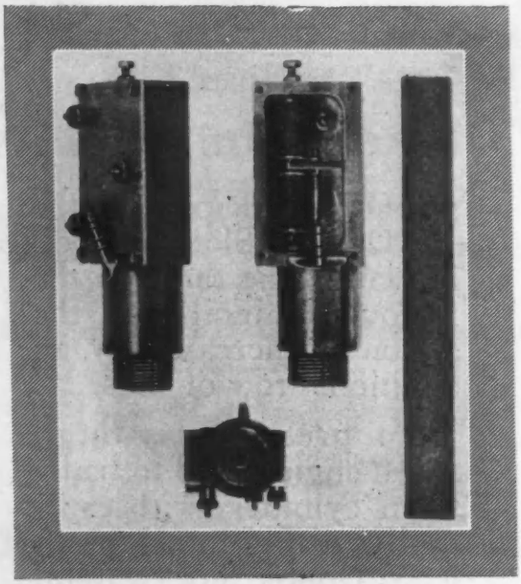

This equipment is built by O. S. Peters, inventor of the McCollum-Peters Electric Telemeter, and includes the adaptation of the instrument to indicating internal combustion engines, as developed by the General Motors Research Laboratory.

TYPICAL INDICATOR CARD

Courtesy General Motors Research Laboratory

Designers and Builders of the Southwark-Emery Universal Recording Testing Machines. The electric multiple range recorders of these machines use the Electric Telemeter Pressure Transmitter.

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Notes and Reviews

Continued

edge of the spread between the maximum and the minimum pressure and the time and place at which the various amounts of pressure are exerted. How the over-all pressure changes with changes in speed must also be known. Three operating conditions are of special interest—idling, cruising, and a vertical dive with a stalled engine.

With these general considerations as his background, the author proposes to investigate bearing pressures under the three operating conditions mentioned. To bring out the fundamentals and give an inclusive outlook over the factors involved, the simplest case is first examined, that in which only one cylinder acts on a crank-throw. An engine employing a master connecting-rod is then considered. The next division of the article includes the investigation of an X and a nine-cylinder radial engine, and a comparison of the effect of concentric and eccentric linking of the connecting-rods. Finally, the crankpin pressure in a 12-cylinder V-engine is determined.

Détermination Expérimentale des Tensions dans les Charpentes d'Avions. By W. Margoulis. Published in *L'Aéronautique*, March, 1929, p. 81. [A-1]

An apparatus for the measurement of tensile stresses in the framework of aircraft is here described. The device is based on an interferometer previously developed for the determination of elastic deformation in heavy metallic structures. The instrument in question is made of duralumin and is light and easily transportable. An example of the use of the instrument in investigating the strength of the fuselage of a pursuit plane is given and the principles of its operation explained.

L'Etat Actuel et l'Avenir du Dirigeable; le Voyage du Graf Zeppelin. By C. Martinot-Lagarde. Published in *La Technique Moderne*, Feb. 15, 1929, p. 97. [A-1]

Basing his remarks on the performance of the Graf Zeppelin, the author attempts to orient heavier-than-air craft in the general scheme of air transportation. The latest dirigible to cross the Atlantic, he concedes, revealed that important technical progress has been made in certain directions; ability to live through bad weather; realization of unvarying force of ascension through the use of fuel of the density of air; regularity of performance of the 500-hp. engines for 100 hr. of uninterrupted operation; and the accuracy of navigation. The Graf Zeppelin is not considered, however, as a proper vehicle for regular oceanic transportation.

Should France utilize its airship hangars, the largest of their type in the world, to make up its backwardness in the development of dirigibles? In answering this question in the negative, the author states that France is not in the position of England and America, which can make large financial sacrifices to develop a real air navy and which contemplates the war-time use of dirigibles to accompany warships on the high seas and to maintain communication with distant colonies. France's African empire is said to be within the radius of hydroplane operation and its coast surveillance to require only small airships. For rapid international communication, airplanes are the most suitable agents.

In the article, the development of the airship is traced, problems analyzed, and the Graf Zeppelin described in detail.

Dictionary of Aeronautical Terms. By J. Vanièr. Published by the American Society of Mechanical Engineers, New York City; 141 pp. [A-3]

Readers of foreign literature interested in aviation will welcome this three-language dictionary of technical aeronautical terms. It is an abridgement of a complete volume and appeared originally in smaller form for use in the Army Air Corps Engineering School. It consists of two

(*Continued on next left-hand page*)

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Notes and Reviews

Continued

sections, a German-English-French and a French-English-German section. An effort has been made to render the volume widely serviceable, and in the case of a choice between a technical and a popular term, the latter, if equally correct, has been preferred. The compiler has been a translator of technical data in Europe and a member of the staff of the Matériel Division of the Army Air Corps in a similar capacity.

CHASSIS PARTS

Une Nouvelle Suspension. By René Charles-Faroux. Published in *La Vie Automobile*, March 25, 1929, p. 107. [C-1]

When a vehicle in motion passes over an obstacle, the wheel is displaced along a line inclined at an angle of about 70 deg., the author points out. The reaction of the shock is made up of two components, one horizontal, the other vertical, only the latter being absorbed by classical suspension systems. As an improvement, the designer Peyruquéou arranges his suspension so that its plane of flexion is inclined 70 deg. toward the rear, thus providing for the absorption of the entire reaction. Further, the spring is connected to the wheel not rigidly, but by a sliding system of connections, permitting a horizontal displacement in its own plane; hence the velocity of the wheel on passing over the obstacle is not necessarily as great as the velocity of the vehicle.

A reduction of one-fourth to one-ninth in the shock to be absorbed by the springs and the tires is said to result from these two provisions. An additional contribution to riding comfort is the reduction in the unsprung weight made possible by the lessening of the shock and the consequent fatigue.

Descriptions of the suspension as applied to a Cottin-Desgouttes and an Itala sport car are given.

Frames Get Heavier, Springs Lighter, in Last 12 Years. By P. M. Heldt. Published in *Automotive Industries*, March 30, 1929, p. 514. [C-1]

The author has made a very interesting analysis of the weight distribution in the chassis of eleven 1929 passenger-cars and compared the average weight of the various parts with similar data gathered by the author 12 years ago. The comparison shows a marked shift in weight distribution, which Mr. Heldt attributes to a change in design rather than to any very great reduction of excess weight or improvement in placing the weight. According to the tables included in the article, frames have increased in weight more than 40 per cent, while springs have decreased by 27.6 per cent. The increasing use of closed cars is cited as a probable reason for the increased weight of the frame; while the use of balloon tires and alloy steels, together with improved roads, may help to explain the use of lighter springs. Four-wheel brakes are also listed as bearing considerable responsibility for the change that has taken place in chassis proportions since 1917.

ENGINES

Automatic Spark-Advance. By H. S. Rowell and C. G. Williams. Paper presented before the Institution of Automobile Engineers, April 9, 1929, London. [E-1]

The importance of accurate spark-timing is convincingly set forth in the test results given in this article. The author lists the advantages of automatic control, which eliminates the time lag due to lethargy or ignorance on the part of the driver and allows him to devote more of his attention to the other controls. As a preliminary to discussing the design of a rational spark-adjusting mechanism, the more important factors affecting spark timing are considered; namely, engine size, shape and speed; turbulence, fuel-air ratio and exhaust-gas dilution of the explosive mixture;

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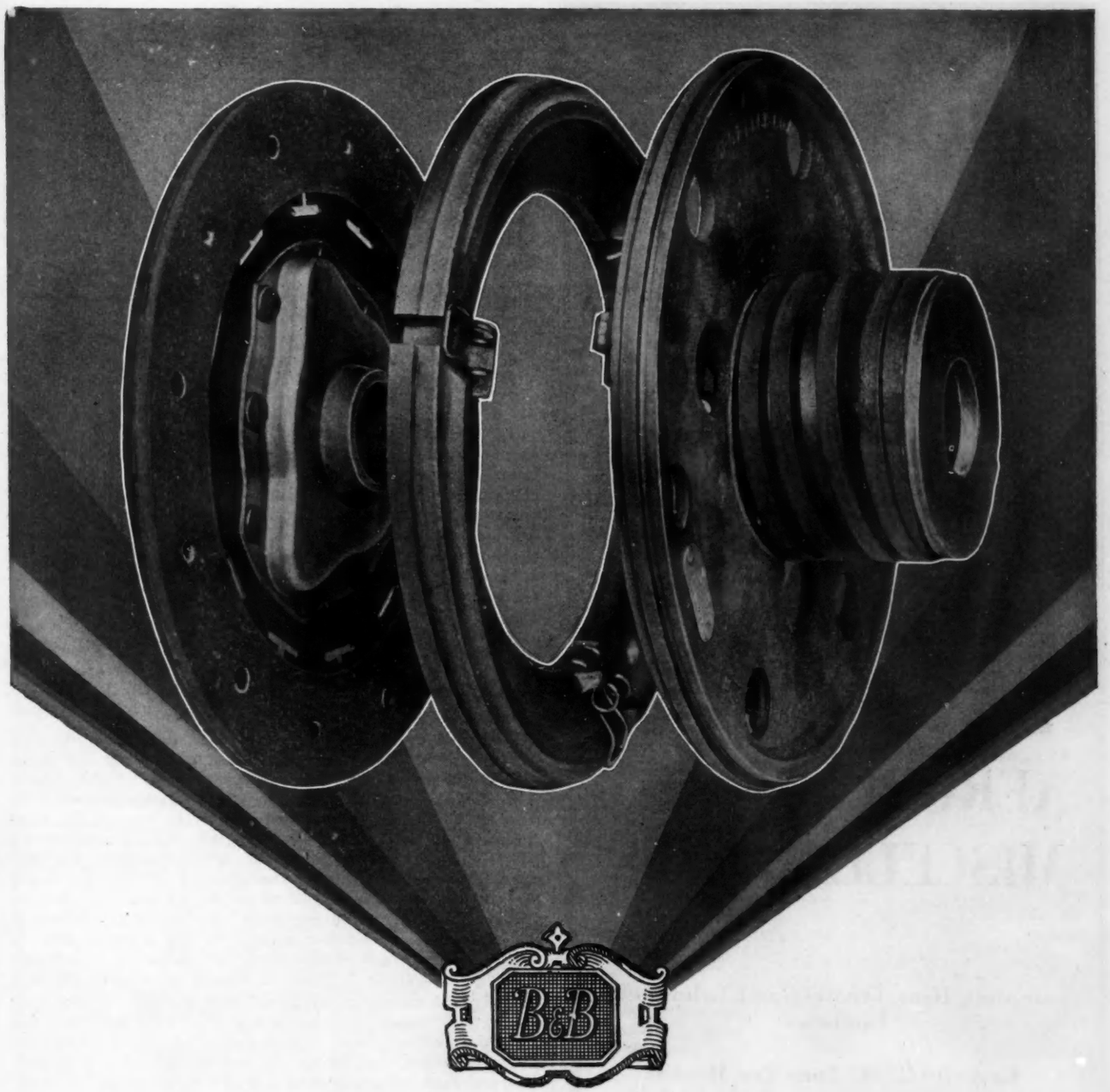

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Notes and Reviews

Continued

and general condition of the engine. These factors are treated as practical problems, and from experimental results on diverse engines it is concluded that an exact automatic adjustment appears, in general, to be impracticable; therefore manual control is desirable in addition to any simple automatic system. Typical mechanisms for speed control are analyzed, and a suggested throttle mechanism for combination with speed control is described.

The Transformation of Heat in an Engine. By Kurt Neumann. Technical Memorandum No. 509. Translated from Geiger and Scheel's Handbuch der Physik, chapter 9, vol. XI, 1926, by the National Advisory Committee for Aeronautics, City of Washington; 28 pp., 13 figures. [E-1]

The chapter deals with the transformation of heat in the engine. The division of the chapter translated deals with engines the operation of which is based on the liberation of chemical energy; that is, internal-combustion engines. The treatment of such engines from the standpoint of classical thermodynamics is important, for it forms a necessary introduction to their further investigation that must include a consideration of the thermodynamics (and kinetics) of the gaseous explosive reaction on which their operation depends.

Les Moteurs Diesel Légers pour l'Automobile et l'Aéronautique. By G. Delanghe. Published in *Le Génie Civil*, March 23, p. 277; March 30, p. 306, and April 6, 1929, p. 328. [E-1]

Prompted by the distinct advance in the development of light Diesel engines, the author has undertaken this analysis of the present and possible future place of this type of power-plant in the automotive and aeronautic field. He sees, for the present, three obstacles in the way of the widespread adoption of the Diesel engine: its weight, lack of flexibility, and the delicacy of certain parts. He also raises the question whether the growing demand for heavy fuels will permit the Diesel to retain its economic superiority. However, while decrying the excessive claims of the enthusiast, the author accords to the Diesel engine of the future an increasingly important place in automotive transport, particularly that of commerce and industry.

A general discussion of Diesel-engine design is given, in which two classes are contrasted, the solid-injection and the air-injection types. The former is in turn subdivided into two groups, one having the fuel introduced directly into the combustion-chamber and the other employing an antechamber for the reception and preliminary preparation of the fuel.

MATERIAL

Minutes of Conference on Heat Transfer by Radiation and a Brief Synopsis of Present Knowledge on Radiation of Heat. Mimeographed by the Committee on Heat Transmission, New York City, 1929; 21 pp. [G-1]

In view of the ever-increasing importance of heat transfer by radiation in many industrial and engineering applications, the executive committee of the Committee on Heat Transmission, Division of Engineering and Industrial Research, of the National Research Council, authorized the formation of a subcommittee to deal with this matter

The report here reviewed is a preliminary outline of what is and what is not known in this field, and was prepared after the first meeting of the subcommittee. Suggestions are sought as to either increasing the scope of the undertaking or improving the matter included. A bibliography on heat transfer by radiation is appended.

(*Continued on next left-hand page*)

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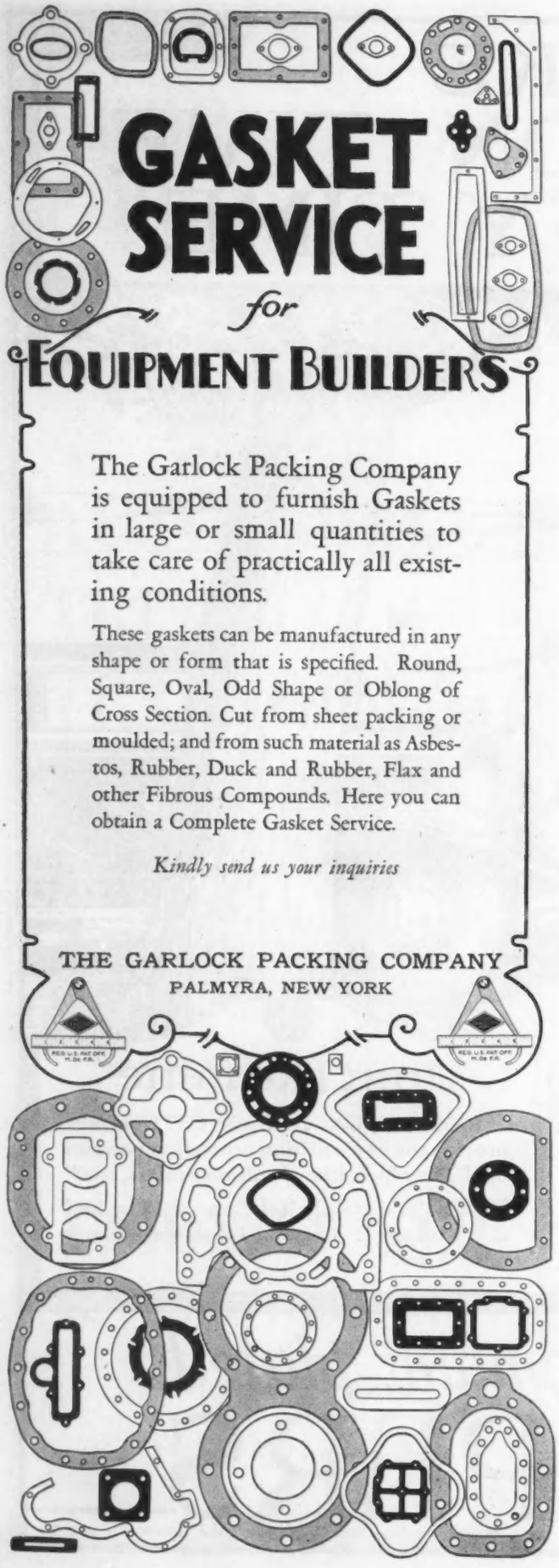
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Notes and Reviews

Continued

Standardization of Conditions for Measuring the Detonation Characteristics of Motor Fuels. By R. Stansfield and F. B. Thole. Published in *Industrial and Engineering Chemistry*, Analytical Edition, April 15, 1929, p. 98. [G-1]

Three designs of engine having entirely different combustion-chamber shapes and valve arrangements are described. The results of tests conducted in the engine research department of the Anglo-Persian Oil Co., England, are quoted to show that substantially equal results for antiknock value can be obtained from any of the engines if comparisons are made in terms of equivalent blends of standard spirits and provided that test conditions are suitably controlled. The effects of the controllable variables are examined and definite conclusions drawn. It is suggested that N-heptane and pure benzene are suitable for standard reference blends, but there is need for a cheaper and more easily obtainable low-value spirit than heptane.

Prüfverfahren zur Beurteilung der Korrosionsbeständigkeit von Metallen gegen Witterung und Seewasser. By Erich Rackwitz and Erich K. O. Schmidt. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, March 28, 1929, p. 137. [G-1]

In the interests of securing more uniform methods of corrosion testing, the authors present in this article a series of investigations carried out over a period of years by the Deutsche Versuchsanstalt für Luftfahrt (German institution for aeronautical testing). The experimental methods were developed primarily for the testing of light metals and their alloys, and special efforts were made to obtain reproducibility of test findings and a correlation between laboratory determinations and practical results.

The Mylius accelerated tests were found after investigation to be unsuitable for light metals and, further, 24-hr. accelerated tests as a whole were abandoned in favor of methods the apparatus and operations of which are here described. Some results are given in terms of reduction of area, loss of weight, intercrystalline corrosion and change in strength characteristics.

Carbonization of Lubricating Oils and Fuel Oils. By N. I. Chernojookov. Published in *Industrial and Engineering Chemistry*, April, 1929, p. 315. [G-1]

The results of several series of tests to determine the coke-formation tendencies of lubricating and fuel oils under varying conditions of temperature and pressure are given in tabular form and the following conclusions drawn:

(1) Under the conditions of the Conradson carbon-residue test, the carbonization of the oils depends on the amounts of asphaltenes and tars present in the given oil. Colorless oils and paraffins do not give appreciable amounts of coke when evaporated in the Conradson apparatus.
(2) The carbonization values of Conradson are not representative of the carbonization of oils in service.
(3) More reliable information can be obtained by determining the stability of the oils with regard to sludge formation. This method is based on the oxidation of oils by oxygen or air under high temperatures and pressures.
(4) Different crude oils, lubricating oils, and their tars give different amounts of sediment or sludge under the same conditions of oxidation.

Index to A.S.T.M. Standards and Tentative Standards. Published by the American Society for Testing Materials, Philadelphia; 95 pp. [G-3]

This pamphlet constitutes a combined index to all the A.S.T.M. standards and tentative standards in effect as of

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Notes and Reviews

Continued

Sept. 1, 1928. The Index is designed to be of service to those who are familiar with the Society's standards in locating any specification or method of test in the bound publications in which it appears, and, as well, to those interested in ascertaining if the Society has issued any standards on a specific subject.

Welding Aluminum and Its Alloys. By W. M. Dunlap. Published in *Aviation*, aeronautical engineering section, Mar. 16, 1929, p. XL. [G-5]

Welding is classified under three principal processes: forge welding, in which the weld usually is completed by the application of a hammer blow when the metal is in the plastic state; pressure welding, in which the metal is welded by mechanical pressure while in the plastic or molten state; and fusion welding, done without mechanical means and with the metal in the molten state. The last-named is the most satisfactory method for aluminum welding, especially when the oxy-hydrogen or oxy-acetylene torch is used, asserts the author. Detailed descriptions are given of the steps in the process, and the precautions to be taken to assure satisfactory results are stated. The article is abundantly illustrated.

MISCELLANEOUS

Research in Germany. By J. M. Spitzglass. Published in *Mechanical Engineering*, April, 1929, p. 275. [H-1]

Mr. Spitzglass presents in this article a very interesting account of his personal observations of the general tendencies and peculiarities of industrial developments in Germany and compares them with the research activities in our own Country. He points out that, as a general comparison, it may be said that society research is more open and more cooperative in Germany than in the United States, while individual or private research in the industrial field is somewhat more secret and individual than it generally is here. In concluding he states:

> I have observed with interest the tendency toward Americanization in the field of research, but that tendency does not convey the same impression that the old label "Made in Germany" used to in the United States. It is a tendency toward obtaining similar results but not necessarily by identical means. Therefore it behooves us to make a closer study of the methods employed for cooperating the groups of society research in Germany, to see whether such methods could not be applied equally well in certain cases of society research in the States.

A valuable addition to the article is a list of research projects completed, under way, or authorized in Germany at the beginning of 1928.

Die Wirtschaftliche Automobilwertung. By E. A. Tschudakoff. Published in *Der Motorwagen*, March 10, 1929, p. 137. [H-1]

The rules and formulas used by the institution for automobile and engine testing at Moscow for determining fuel economy in relation to performance are here set forth.

In the first section are discussed factors affecting the economical operation of the engine. Consideration is given to the fact that measurements made on the engine alone will bear no real practical relation to its performance in a vehicle, since it seldom operates at full throttle and its performance depends on the dimensions and speed of the vehicle and on road conditions. Curves are developed showing the effect on fuel consumption of various degrees of throttling at various engine-speeds. As practical illustrations, similar curves are given for a Fiat and an Amo car. Engine and car speeds are next correlated, the question of mechanical efficiency considered, and the effects on fuel consumption of tractive resistance and grades encountered are graphically represented.

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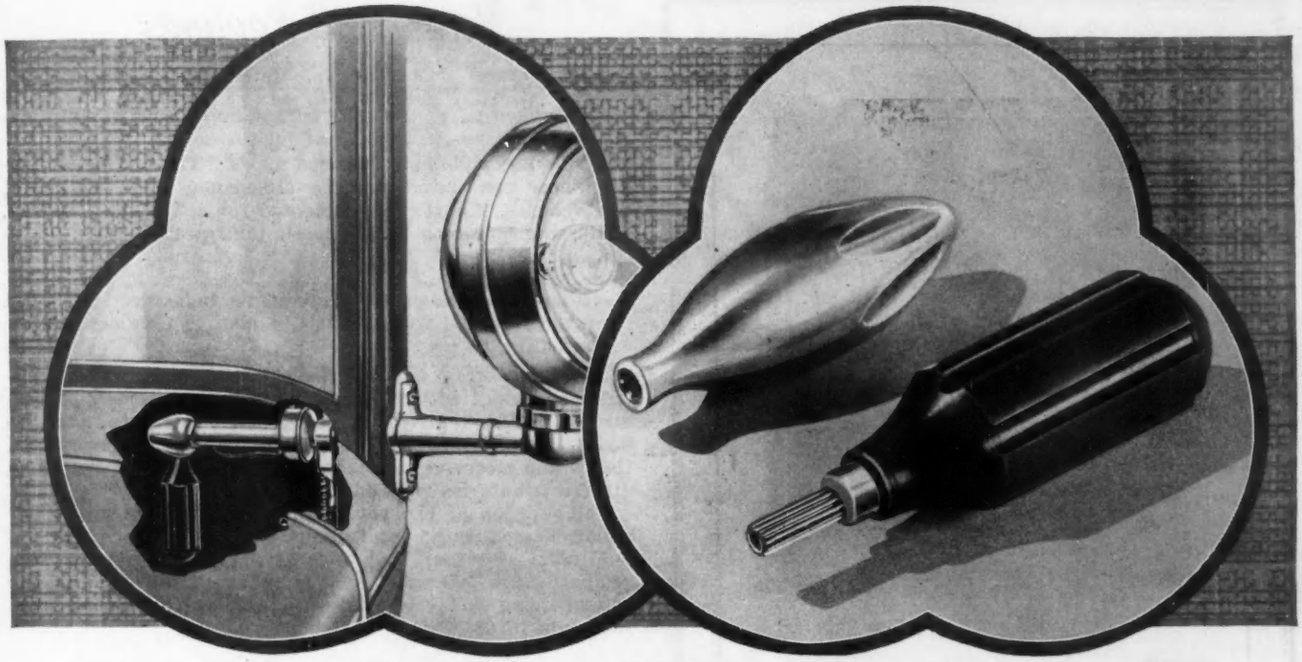

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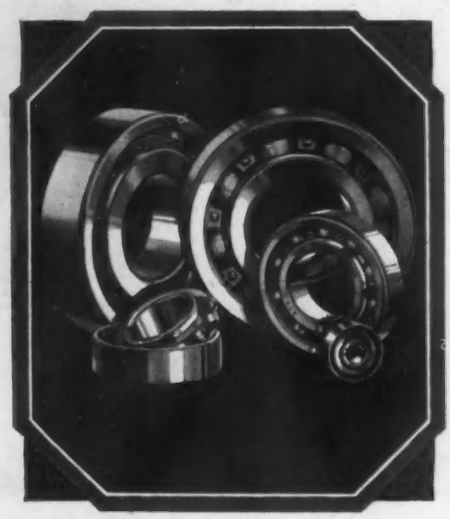

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Notes and Reviews

Continued

In the second section, the author builds up on the material already presented to work out the actual fuel consumption for automobiles of various types. The additional factors here considered are the dimensions and weights of the vehicles. Curves are presented for a Trojan, a Lancia, a Büssing motorcoach, a Renault taxicab and truck, and a Sauer truck.

Facts and Figures of the Automobile Industry. Published by the National Automobile Chamber of Commerce, New York City, 96 pp. **[H-3]**

The 1929 edition of this valuable little book is now available and bulges with facts and figures on all phases of production, sales, registration, and distribution of motor-vehicles. Employment figures in the industry, highway statistics and motor-vehicle taxes are only a few of the many diverse tributaries covered.

Computation of the purchasing power of the automobile dollar, based on the total annual production and total annual value of output, show it to be worth 113 cents today as compared wih 100 cents in 1914, whereas the value of the cost-of-living dollar has decreased during this period from 100 cents to 62.

Vibration Problems in Engineering. By S. Timoshenko. Published by D. Van Nostrand Co., Inc., 1928; 346 pp., illustrated. **[H-3]**

Professor Timoshenko's book will be welcomed by that growing group of engineers to whom analysis is a powerful tool of investigation and not merely an "academic" pastime. A glance at the contents showing the nature and range of problems dealt with is sufficient to bring out the very practical importance of the work. The book is divided into four chapters and an appendix.

Chapter I, on Harmonic Vibration, deals with the free and forced vibrations of simple systems having one degree of freedom, and includes such interesting topics as Rayleigh's method of determining free frequencies, effect of spring mass on a simple vibrating system, the integral method of calculating forced vibration, balancing of rotating parts, and critical speed of rotating shafts.

Chapter II, on Non-Harmonic Vibration, treats of systems with one degree of freedom which lead either to non-linear differential equations or to linear equations with variable coefficients; i. e., systems wherein the restoring force depends on the displacement but is not proportional to it, or wherein the spring constant involves the time explicitly. The unfortunate mathematical difficulties to which such equations lead are circumvented either by graphical methods or by methods of successive approximation, in the simpler cases. The problem of vibrations in the side-rod drive system of electric locomotives is treated in great detail.

Chapter III, on System Having Several Degrees of Freedom, introduces Lagrange's equations in a simple and lucid manner and illustrates their use by the problem of the spherical pendulum. Both free and forced vibrations are treated in a general manner and illustrated by specific examples; e. g., a massless string with discrete loads, pitching oscillation of an automobile body, torsional vibration of straight shaft, crankshaft, geared systems; lateral vibration of shafts on many supports; gyroscopic effects on critical speeds; theory of dynamic vibration absorber, and so on.

Chapter IV, on Vibration of Elastic Bodies, occupies about one-third of the book and deals largely with fundamental problems which are treated in such classics as Rayleigh's theory of sound. and, indeed, affords a good introduction to the more advanced works on the subjects. In addition, many practical problems are treated in this chapter, such as vibration of bridges, of beams on an elastic foundation, of turbine blades and discs, and of hulls of ships.

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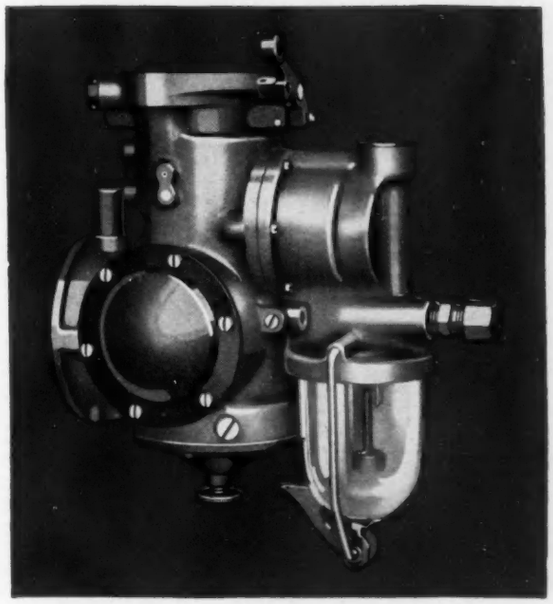

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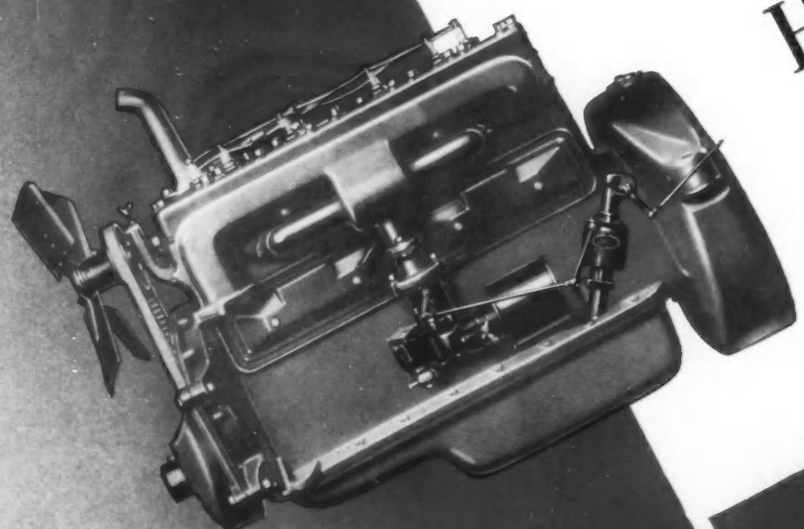


Care at every step

In the conduct of every operation in the manufacture of Bethlehem Alloy Steels the knowledge is kept uppermost that these steels are to be used in places where exceptional strength and reliability are required.

The most meticulous care is exercised at every step to insure that Bethlehem Alloy Steels are as nearly perfect as it is possible to make them. These steels are made in a separate unit of the Bethlehem organization devoted solely to alloy and special steel manufacture. In their production the most modern steel-making equipment is combined with the constant exercise of highly developed human skill and judgment. The men who make Bethlehem Alloy Steels realize fully the vital importance of the tasks that will be entrusted to these steels, and, at every step, exercise the utmost possible care to work into them the maximum of strength and endurance.

From the earliest days of the automotive industry, manufacturers have been coming to Bethlehem for alloy steels. Today they are coming in larger numbers and for larger quantities than ever before.

BETHLEHEM STEEL COMPANY

General Offices: Bethlehem, Pa.

District Offices: New York, Boston, Philadelphia, Baltimore, Washington, Atlanta, Pittsburgh, Buffalo, Cleveland, Detroit, Cincinnati, Chicago, St. Louis, San Francisco, Los Angeles, Seattle, Portland and Honolulu.

Bethlehem Steel Export Corporation, 25 Broadway, New York City
Sole Exporter of our Commercial Products

BETHLEHEM
ALLOY STEELS

Because of their "Oil Tight" (Oil lubricated) feature and mechanical perfection in every detail MECHANICS UNIVERSAL JOINTS have been selected by the Moon Motor Car Company as standard on the popular Windsor 8-92. This is further evidence of automobile manufacturers' preference for the satisfactory, long service delivered by Mechanics Joints.

"Built as Only Mechanics can Build"

The popularity of Mechanics Joints among passenger car manufacturers, well known for their volume production, assures you lower unit cost in our plant.

Use Our Engineering Service When Planning Your New Models

The services of our Engineering Department are available to you for assistance in solving your universal joint problems, without any obligation. When planning new models call on these men.

This service is offered free.

MECHANICS UNIVERSAL JOINT CO.
ROCKFORD, ILLINOIS

Sales Representatives	*Export Representatives*	*Foreign Representatives*
C. A. S. Engineering Co. 5-139-140 General Motors Bldg., Detroit, Mich.	Benjamin Whittaker, Inc. 114-118 Liberty St., New York, N. Y.	Benjamin Whittaker, Ltd. Aldwych House, Aldwych, London, W.C. 2, England

Notes and Reviews

Concluded

Unfortunately, the book abounds in typographical errors, especially in the frequent omission of dots indicating time differentiation; and often the steps are not clear; some deductions are given in fragmentary form which would better have been omitted or else adequately presented; e. g., Horner's method. The treatment of "vibrographs" on p. 35 involves an error in that it omits the forcing action of the friction, an error which becomes very important when the damping is large. This type of error has been made by other writers, and it is unfortunate that it should be perpetuated by so excellent an authority as Professor Timoshenko.

The appendix describes various instruments used in the measurement of vibrations, but omits some recently developed devices which bid fair to become important.

The defects mentioned, however, are small in comparison with the general importance of the book.—Benjamin Liebowitz.

MOTORCOACH

Bus Facts for 1929. Published by the National motor bus division, American Automobile Association, City of Washington; 47 pp. [J-4]

This is another annual compilation of all important statistical information bearing on motorcoach operation which has been brought to light by individuals, trade publications and authoritative research agencies during last year. The National Motor Bus Division is now in the fourth year of its existence, and all activities that promote the welfare and prosperity of motorcoach operators and of the motorcoach industry as a whole are within the scope of the division's program.

A map of the United States showing a total of 270,000 miles of intercity motorcoach operation is attached to the back cover of the pamphlet.

PASSENGER-CAR

Air Resistance of Automobiles. By E. H. Lockwood. Published in *American Highways*, April, 1929, p. 1. [L-1]

At the recent sessions of the Highway Research Board, City of Washington, Professor Lockwood presented this report of the air-resistance tests conducted at Yale University during 1928. The coasting method for determining air resistance was suggested, and preliminary tests convinced the investigators of its accuracy. The experiments were conducted on a smooth road of uniform grade, not exceeding about 6 per cent. The car was allowed to coast down the hill in neutral gear, using an accurate tachometer for measuring the coasting speed. The rolling resistance of the vehicle was measured by a chassis dynamometer, at the same speed, load, and so forth as during the coasting test, and the vehicle weight, including observers, was determined and the projected area for air resistance measured.

Tables showing the rolling resistance over a wide range of speeds for a Chrysler, a LaSalle and a Packard car are given, together with the air-resistance figures for the various body types—sedan, roadster, phaeton and so on—on a number of different makes of car. The coasting tests reported seem to indicate that each type of body has its own characteristic coefficient in the air-resistance formula, and that each road may have its influence in modifying the air resistance.

In appraising the value of the different methods of measuring air resistance, the author points out that the coasting method has the advantage of a full-sized vehicle actually traveling on a smooth road at considerable speed in still air. Under these conditions, the true air resistance acts on the vehicle, but its accurate measurement is dependent on the chassis dynamometer, where the rolling resistance is determined.

The giant steel skeleton of a ship

FOR every bolt and rivet that goes into the framework of a ship, a hole must be cut through hard, unyielding steel.

In the world's great ship yards, big husky W & B drills are standing staunchly up to their work—proving that rugged quality of endurance that has made them famous through the years.

In this spectacular era, when speed is a fetish, when competition faces low costs, when manufacturing accuracy is essential—industry pays particular attention to its tools.

There is a very real advantage in turning for drills, reamers and cutters to an organization that has specialized in the design and manufacture of cutting tools for more than three quarters of a century.

WHITMAN & BARNES

DETROIT, MICH.

Canadian Factory: Canadian-Detroit Twist Drill Co., Limited, Walkerville, Ont.

TOOL MAKERS FOR 78 YEARS

Exactly and Always

Interstate has made hundreds of thousands of tons of alloy steels for large users who know steels as well as any steel manufacturer. And Interstate constant quality has consistently met the rigid demands of the country's largest users for years. You can depend upon it that Interstate precise manufacture will meet your particular requirements exactly—and always!

INTERSTATE IRON & STEEL CO.
104 South Michigan Avenue
CHICAGO

Open Hearth Alloy Steel Ingots, Billets, Bars, Wire Rods, Wire, Nails, Cut Tacks, Iron Bars and Railroad Tie Plates

Interstate Alloy Steels

District Offices:
NEW YORK—52 Vanderbilt Avenue
DETROIT—Washington Boulevard Building
MILWAUKEE—First Wisconsin Nat'l Bk. Bldg.
ST. PAUL—Merchants National Bank Building
ST. LOUIS—International Life Building
KANSAS CITY—Reliance Building

Personal Notes of the Members

(*Continued from page 667*)

Member in 1928. He became a Detroit Section member in 1925 and in 1928 transferred his Section membership to Northern California. His absorbing interest in aircraft has made Mr. Thaden a keenly interested participant in the aeronautical activities of the Society. He presented a paper on the construction of metal aircraft at the Production Session of the National Aeronautic Meeting held last September in Los Angeles.

Whitaker Joins Szekely

John T. Whitaker, one of the original advocates of organizing the Society on the basis of professional groups or activities, has relinquished his position as manager of the automotive division of the Tide Water Oil Sales Corp., in Detroit, and is now building airplanes and engines as vice-president of the Szekely Aircraft and Engine Co. at Holland, Mich.

In assuming this position, he is entering a new field, the major part of this technical experience having been in transportation engineering. His first automotive venture was undertaken in 1914, when he owned and operated the Rio Grande Auto Stage & Sales Co., a passenger bus service, at Brownsville, Tex. In 1917 he joined the Signal Corps of the United States Army, being commissioned a transport officer, and served overseas with the American Expeditionary Forces. In 1919 he accepted a position with the Postal Telegraph Co., in New York City, as superintendent of transportation and several years later left this company to engage in transportation engineering for The White Co., at Cleveland. In the succeeding years he became affiliated with the American LaFrance Fire Engine Co., Inc., at Elmira, N. Y., in the capacity of branch manager, and the Carvite Mfg. Co., Inc., of Albany, as vice-president. He severed the latter connection in 1927 to join the Tide Water Oil Co. as automotive engineer.

Mr. Whitaker, who was elected to Associate membership in the Society in 1927, was a sponsor of the Aviation Division of the Detroit Section, and this year is serving as chairman of the Division's Membership Committee. He is also an associate member of the American Institute of Electrical Engineers.

Berdon in East Orange

Albert E. Berdon, research engineer of noted achievements, who was previously located at Detroit as a consulting engineer, is now established in East Orange, N. J., as a consulting and research engineer.

Mr. Berdon's first and longest affiliation in the automotive industry was with the Esterline Co., in Lafayette, Ind. During his 10 years' service with this company he had charge of the design and construction of special electrical and mechanical testing machinery and apparatus. During the last five years of this association, while chief engineer, he developed and designed the different instruments and equipment manufactured by the Esterline Co. and became the holder of numerous patents in connection with his inventions. In 1925 he served as engineer of production for the Remy Electric Co., of Anderson, Ind.

In 1917 Mr. Berdon accepted the position of research engineer with Dodge Brothers and, at the time of the severance of this connection, in 1921, he entered the independent field of engineering in Detroit. Subsquently he joined the Self Feeding Vaporizer Corp., in New York City, and later the Eisemann Magneto Corp., of Brooklyn. He resigned as assistant chief engineer of the last-named company in 1926 to open engineering offices in Detroit.

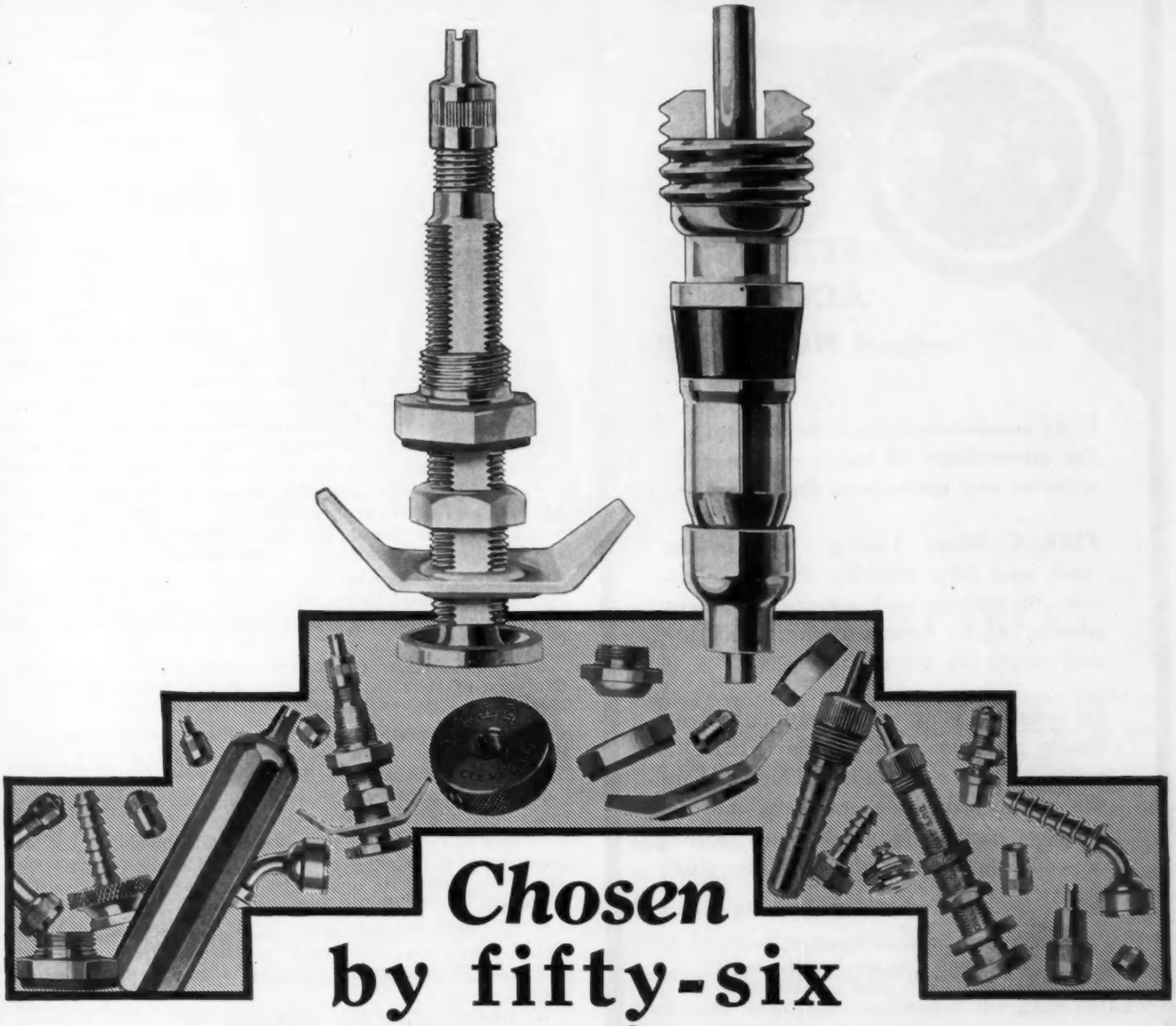
Mr. Berdon, who received the degree of bachelor of science in electrical engineering from Purdue University in 1907, has been a Member of the Society since 1912 and of the Detroit and Metropolitan Sections since 1917.

John W. J. Ackermans has joined Dietrich, Inc., at Detroit, having resigned his position as draftsman with the Pierce-Arrow Motor Car Co., of Buffalo.

(*Continued on next left-hand page*)

DILL

Standard Tire Valves and Valve Parts



Chosen by fifty-six *tire manufacturers*

THE fact that the Dill Manufacturing Company is supplying Valves and Valve Parts to fifty-six tire manufacturers should be of tremendous significance to every executive in the automobile and rubber industries.

It is evidence, of the most convincing kind, that Dill design, Dill workmanship, Dill standards of manufacture, and Dill quality have met the most severe requirements—and have proved their merit.

THE DILL MANUFACTURING COMPANY
Cleveland, Ohio
Manufactured in Canada by the Dill Manufacturing Co., of Canada, Ltd., Toronto, Canada

FIBROC Moulded Silent Timing Gear with Metal Hub

STRENGTH
ACCURACY
—and NO NOISE

High compression, high speed motors in the automobiles of today require more accurate and more quiet timing devices.

FIBROC Silent Timing Gears in the front end drive provide absolute accuracy in timing, and assure permanent silence, which means greater efficiency and longer life for the motor.

In ordering your next supply of silent timing gears, insist on genuine FIBROC material. The cost will be no higher than the cost of ordinary silent gears, and the greater accuracy, longer life and silence of your timing assembly will be most gratifying.

FIBROC Moulded Timing Gears are furnished in any quantity to specification — with or without hubs.

FIBROC

FIBROC INSULATION CO.
315 Linco'n Avenue
VALPARAISO, IND.

Personal Notes of the Members

Continued

Nels G. Anderson recently joined the Aristo Corp., in Detroit, as sales manager. His former position was chief engineer for the International Harvester Co., of Springfield, Ohio.

Harold A. Backus, until lately chief of the materials department of the Curtiss Aeroplane & Motor Co., of Garden City, Long Island, N. Y., has joined the forces of the Berliner-Joyce Aircraft Corp., of Baltimore.

Robert H. Bigler, former Ohio State University student, has been appointed physicist in the research laboratory of the A C Spark Plug Co., of Flint, Mich.

John A. Binder has given up his position as service representative with Dodge Brothers, in Detroit, to assume charge of the experimental laboratory of the Durant Motor Co., also in Detroit.

W. R. Boysen, formerly sales engineer with the Hyatt Roller Bearing Co., in Detroit, is now associated with the Diamond Chain & Mfg. Co., in the same city.

George A. Breeze, previously carbureter engineer with the Oakland Motor Car Co., has resigned to become associated with the Tapley Car Performance & Brake Testing Meters Co. as sales engineer in the Michigan territory.

G. H. Brown is now supervisor of service in the Memphis district for the Oakland Motor Car Co., of Pontiac, Mich. He previously acted as factory service representative.

H. Fletcher Brown recently announced his resignation as chief engineer of the Eagle Iron Works and his acceptance of the position of field manager for the Yellow Cab Airways, Inc. Both companies are located in Des Moines, Iowa.

Charles L. Burns, now assistant to the factory manager of the Pratt & Whitney Aircraft Co., of Hartford, Conn., was formerly in the engineering department of the American Machine & Foundry Co., in Brooklyn, N. Y.

Gerald A. Christopher has resigned as sales engineer for the Lott Universal Roller Bearing Corp., in New York City, to assume a similar position with the Heywood Starter Corp., in Detroit.

Roy E. Cole has resigned as chief engineer of Dodge Brothers, of Detroit, to accept a similar post with Durant Motors, Inc., also in Detroit.

David J. Conant, who until recently was affiliated with the Layne & Bowler Co., Inc., at Memphis, Tenn., has joined the Westinghouse Electric & Mfg. Co., in East Pittsburgh, Pa. His new duties will be to direct the engineering in the small light and powerplant department.

Arthur E. Corbin has resigned as sales manager for the Fedco System, Inc., in New York City, and is now connected with the commercial division of the Chevrolet Motor Co. at Detroit.

D. E. Crabb recently established a connection with the Wetzel-Frazer Co., of Detroit, as sales engineer. He was previously trim engineer for the Willys-Overland Co., at Toledo.

W. Joseph Cullen, associated with the Sinclair Refining Co., in New York City, has been advanced from sales engineer to staff engineer.

James B. Dick has severed his connection with Fuller & Sons and accepted a position with the Plamondon division of the Foote Brothers Gear & Machine Co., in Chicago.

Russell S. Ellis, who until lately acted as manager for the Foss Hughes Co., in Philadelphia, is now associated with the DeSaint-Phalle & Co., also of Philadelphia.

Harry E. Figgie, formerly manager of sales for the Standard Steel Spring Co., located at Coraopolis, Pa., has been advanced to the post of vice-president in charge of sales.

T. G. Gehre, formerly mechanical engineer with the F. J. Littell Machine Co., at Chicago, has sailed for Sweden, where he will take up his new duties of production manager for the Volvo Motor Car Co., in Gothenberg.

(*Continued on next left-hand page*)

THE ROAD CALLED "UNSURMOUNTABLE"

IN 1920, an automobile manufacturer who had been using Budd open car bodies for six years, asked Budd to build an all-steel closed car body. Until then, no one had ever thought of attempting such a job. It required designs, machinery and stampings entirely different from anything in existence. But Budd had done the impossible before. The order was accepted—a way would be found to fill it.

A way *was* found. Budd's engineering and production executives were called together—the solution of the closed car problem became their especial task. They made good. From their ideas was created a wonderful new automobile body—the Budd all-steel, full vision, closed car body, perhaps the most famous coachwork job on the roads today.

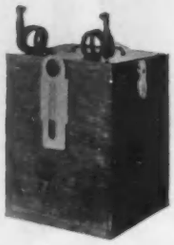
Budd's engineers have been facing "unsurmountable" tasks ever since. And not once have they failed to triumph over them. This is why so many manufacturers now rely on Budd for coachwork counsel. They know of course that Budd has facilities, both in Europe and America, for building any type of body. But more important to them is the knowledge that Budd has the brains and courage to accomplish what others would not dream of attempting—*the impossible!*

BUDD BODIES

BUDD IS THE ONLY BODY-BUILDER IN THE WORLD EQUIPPED TO BUILD ANY TYPE OF BODY

★ ★ ★

Exide a Pioneer



An Exide Sparking Battery of twenty-five years ago.

The modern Exide used on today's passenger car.

Since 1893 Exide Batteries have served the automotive industry. They were first used to propel the early electric horseless buggies. Today, as an outgrowth of that early use, thousands of electric street trucks, mine locomotives and industrial trucks are operated on the power from Exide Batteries.

In the "creeper" days of the "gasoline buggy," Exides were used for sparking purposes. Since 1911, when Exide was standard equipment on the first electrically started and lighted car, that name has been a guarantee to automotive engineers and millions of motorists of a long life of satisfactory battery service.

Exide

BATTERIES

The Electric Storage Battery Co.

Philadelphia

Exide Batteries of Canada, Ltd., Toronto

Personal Notes of the Members

Continued

Herbert Gfroerer has been promoted from district representative for the Dodge Brothers Corp., Detroit, to assistant director of sales in the commercial car and truck division.

B. H. Gilpin has relinquished his position as quality manager of the H. H. Franklin Mfg. Co., of Syracuse, to become service manager of the Pratt & Whitney Aircraft Co., in Hartford, Conn.

J. W. Grumme, Jr., recently established a connection as development engineer in the carrier division of the New York Air Brake Co., of Watertown, N. Y. He previously acted as specification and equipment engineer for the American La France & Foamite Corp., of Elmira, N. Y.

Upon the recent merging of the American Nokol Corp., of Chicago, with the Petroleum Heat & Power Co., now located at Stamford, Conn., **Morgan J. Hammers**, formerly president of the American Nokol Corp., was elected vice-president of the new organization. He will direct all manufacturing by the company.

Richard F. Hardin, formerly associated with the Parks Air College, at East St. Louis, Ill., has established a connection with the Guardian Aircraft Corp. His new position is vice-president and chief engineer.

Mark Harris has been made research engineer for the H. H. Franklin Mfg. Co., of Syracuse. Prior to accepting this position, he was identified with the engineering department of the Buick Motor Co., at Flint, Mich.

R. W. Hautzenroeder, now designer for the Steel Products Engineering Co., of Springfield, Ohio, was formerly designer in the Diesel engine division of the Superior Engine Co., also at Springfield.

Fred C. Hebert has accepted a position with the Seneca Falls Machine Co., in Detroit. Prior to establishing this connection he was affiliated with the Q-C Engineering & Tool Sales, Inc., also at Detroit.

Earle V. Hennecke lately resigned as president Earle V. Henecke, Inc., in New York City, to assume the vice-presidency of the Cooper Corp., at Findlay, Ohio. Mr. Hennecke's headquarters will be in New York City.

Max L. Hillmer, formerly associated with the Delco-Remy Corp. of Anderson, Ind., as superintendent of ignition in the distributor plant, has joined the Guide Lamp Corp., also of Anderson, as factory manager.

E. Edward Hoffman recently assumed his new duties as sales engineer for the Wico Electric Co., at West Springfield, Mass. He used to be chief engineer of the Indian Motocycle Co., also located in Springfield.

L. D. Holland is now connected with Pierce-Arrow Sales & Service, Inc., of Los Angeles, in the capacity of assistant service manager. He was previously shop foreman for William E. Bush, Inc., also of Los Angeles.

Harold Jay has accepted a position in the sales department of the Edward Ford Plate Glass Co., at Rossford, Ohio. Previously he was district manager of the Detroit branch of the Acklin Stamping Co., of Toledo, Ohio.

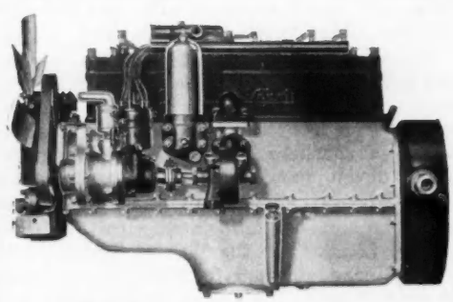
M. L. Jeffrey, formerly works manager of the National Acme Co., of Cleveland, Ohio, has been appointed assistant to the vice-president and general manager of the Wright Aeronautical Corp., at Paterson, N. J. He will assume charge of production activities in connection with the new Whirlwind series.

Emil F. Jirsa, until recently a student at Iowa State College, has been employed by the John Deere Tractor Co., of Waterloo, Iowa, as engineer in the materials engineering department.

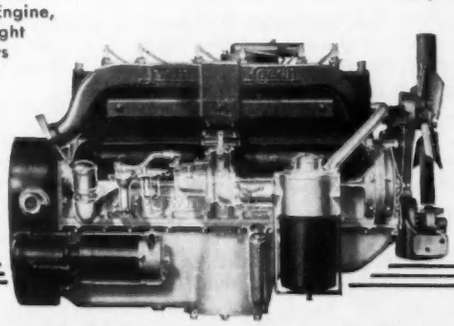
J. O. Johnston has been advanced from assistant works manager to works manager and technical director of Thornycroft (Australia), Ltd., of Sydney, N. S. W., Australia.

(Continued on next left-hand page)

On the Motor City's Bus Lines . . . Hercules Equipped Twin Coaches



The Hercules Twin Coach Engine, Left and Right Side Views



FROM the heart of downtown Detroit, out to the suburbs — through the "rush hour" traffic of Second Boulevard — Hercules equipped Twin Coaches carry thousands of workers every day on one of the city's heaviest traveled lines.

Hercules' reputation as engine builders rests firmly on the basis of performance — acknowledged superior by leading manufacturers who have adopted Hercules Engines as standard equipment on heavy-duty trucks and buses.

HERCULES MOTORS CORPORATION
CANTON, OHIO, U. S. A.
West Coast Branch: Los Angeles, Cal.

HERCULES ENGINES

AETNA
THRUST
BALL BEARINGS

Visit the immense Aetna Thrust Bearing Plant and you sense at a glance the finer bearings that must be produced by manufacturing methods so modern.

The finest steel—the finest workmanship—the very finest machinery available—all contribute to the quality and performance of Aetna Thrust Ball Bearings.

Known the world over as specialists to the industry—Aetna is the logical source for all thrust bearing requirements. Send us your blue prints.

High in Quality and Performance

AETNA BALL BEARING MFG. CO.
4600 SCHUBERT AVE.
CHICAGO, ILLINOIS

Personal Notes of the Members

Continued

Temple N. Joyce has resigned as sales manager of the Chance Vought Corp., Long Island City, N. Y., to assume the duties of vice-president in charge of sales and military development of the Berliner-Joyce Aircraft Corp., in Baltimore.

H. A. Kaplowitz, formerly stationed at the Raritan Arsenal, as junior engineer, has been transferred to the Picatinny Arsenal, Picatinny, N. J. His new title is principal mechanical draftsman.

Hudson W. Kellogg, of the International Motor Co., of Plainfield, N. J., was recently promoted from assistant in the engine laboratory to foreman of the engine testing department.

J. M. Klements, formerly body draftsman with the Chandler-Cleveland Motors Corp., is now acting in a similar capacity for the Studebaker Corp., at South Bend, Ind.

V. B. Koriagin, former student at the University of Michigan, has entered the service of the Mohawk Aircraft Corp., of Minneapolis, as design engineer.

Charles F. Loew, until lately sales manager of the Fay & Bowen Engine Co., located at Geneva, N. Y., has entered the service of the Lycoming Mfg. Co., at Williamsport, Pa.

Alfred F. Masury, vice-president and chief engineer of the International Motor Co., New York City, is now making an extended trip through England, France, Germany, Switzerland and Italy. While abroad, Mr. Masury will visit the factories of foreign automotive manufacturers.

Amos F. Meyer has entered the service of the C. H. Will Motors Corp., at Minneapolis, as a draftsman. He formerly acted in a similar capacity for the Climax Engineering Co., of Clinton, Iowa.

Arthur E. Mignot has resigned as manager of the coil winding and wire enameling department of the Irvington Varnish & Insulator Co., of Irvington, N. J., to undertake the management of the Irvington, N. J., branch of the Rome Wire Co., of Buffalo.

Donald H. Montgomery, formerly treasurer and chief engineer of the Gridley Machine Co., in Hartford, Conn., is now vice-president of the New Britain-Gridley Machine Co., at New Britain, Conn.

L. A. Morgan, until lately service representative of The Buda Co., of Harvey, Ill., has been engaged by the Buda Engine Service, of Tulsa, Okla., to act as salesman.

Robert B. C. Noorduyn recently announced his appointment as assistant to the president of the Bellanca Aircraft Corp., of Newcastle, Del.

George B. Paxton has left the Pennsylvania Power & Light Co., at Harrisburg, where he acted as test engineer, to engage in engine development work in the experimental department of the Pierce-Arrow Motor Car Co., of Buffalo.

Henry A. Pierce, who has been associated with the Brown-Lipe Gear Co., of Syracuse, for the last 11 years, acting as manager of the Chicago branch for the last six years, has severed this connection to become assistant sales manager of the Burgess-Norton Mfg. Co., of Geneva, Ill.

R. J. S. Pigott, formerly consulting engineer for the Smoot Engineering Corp., of New York City, has become identified with Stevens & Wood, Inc., also of New York City, in a similar capacity.

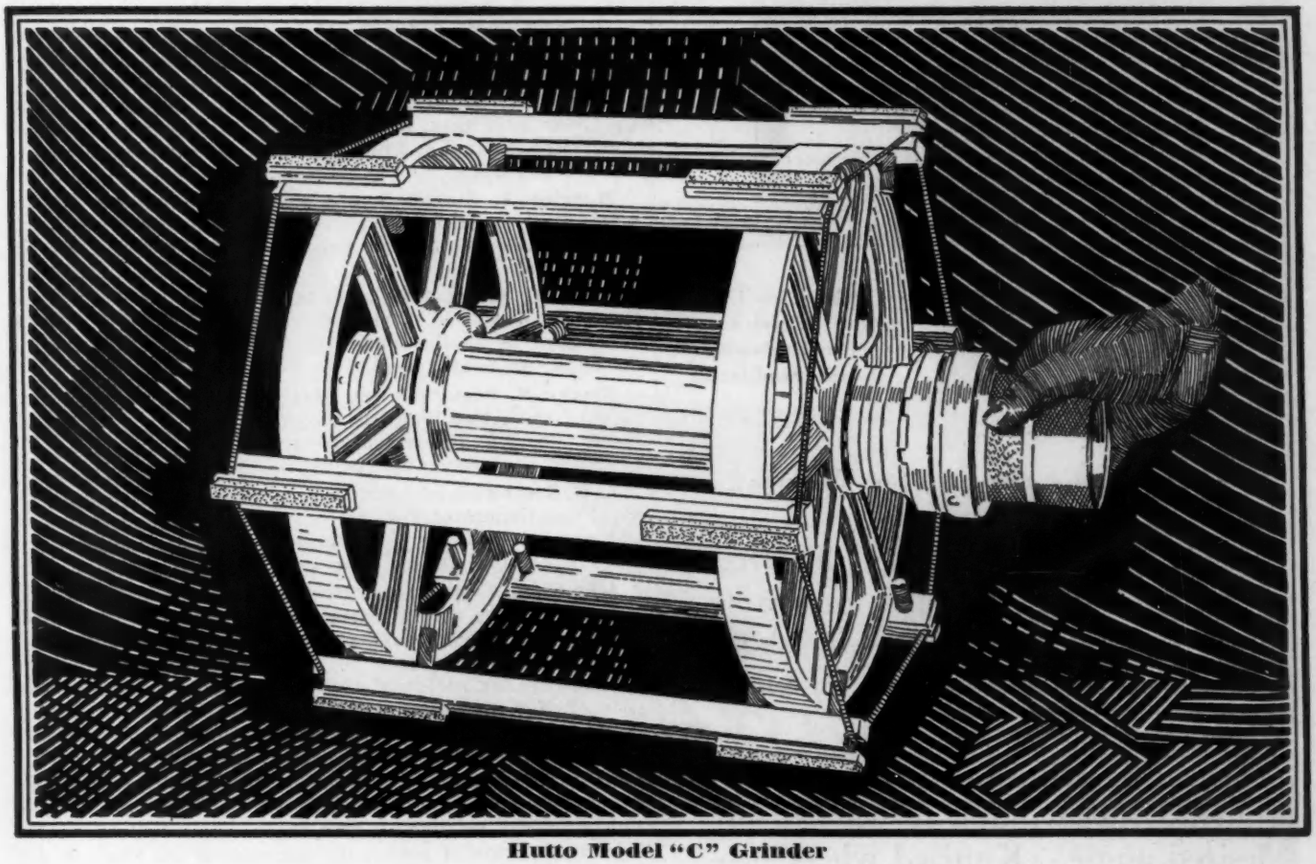
R. C. Pitzer recently joined the forces of Piston Service, Inc., Seattle, Wash., as sales manager. Prior to entering upon this connection, he was sales engineer for the Willis-Jones Machinery Co., also of Seattle.

George E. Pope has given up his position of general service manager with the Locomobile Co. of America, Inc., at Bridgeport, Conn., to take up the duties of sales engineer for the Raybestos Co., also in Bridgeport.

Melville R. Potter, previously service manager of the Genesee Motor Car Co., has accepted a similar position with the Allen Cadillac Corp. Both firms are located in Syracuse.

(*Concluded on next left-hand page*)

How big is *your* job of cylinder grinding?



Hutto Model "C" Grinder

There are Hutto Cylinder Grinders and Machines for all jobs up to 60 inches in diameter

Diameters, lengths of bores, tolerances or time limits are not obstacles. If you have an internal grinding operation on work as small as ¾ths of an inch in diameter or as large as 60 inches in diameter, we can take care of your requirements.

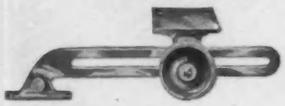
Years of experience building precision grinders for production and service work enable us to assure you greater speed, accuracy and economical operation on internal grinding.

The Model "C" Grinder (illustrated) is designed for cylinders 7 to 30 inches in diameter. Ideal for large bores, such as Diesel engines, air compressors, stationary engines, pump sleeves, valve bodies, locomotive cylinders and similar work.

Our engineers will be very glad to confer with you. Their services are available at your convenience and a request for them to call will not obligate you. Correspondence is solicited.

HUTTO ENGINEERING COMPANY, INC.

516 Lycaste Avenue **Detroit, Michigan**



210-A
Windshield Fixture

Catalog No. 17 will prove helpful to you in your hardware purchases. Send for it.

What Every Operator Wants—

GOOD hardware — trouble-free, long-lived, designed for beauty and practicability—in short, ATTWOOD Automotive HARDWARE.

The sturdy windshield fixture illustrated swings window forward to any desired angle. Knurled wheel provides quick, positive and easy adjustment.

Other items which we manufacture include: Curtain and Drape Brackets, Handles of every kind and for every purpose, Baggage Racks, Baggage Rack Ladders, Bus Steps, Tubes and Rods, Hood Fasteners, and a General Line of Body Hardware.

Chromium Plating, when desired.

Attwood Brass Works - *Inc.*

759-69 Front St., Grand Rapids, Michigan

ATTWOOD Automotive HARDWARE

Personal Notes of the Members

Concluded

William Richards has become identified with the Highland Body Mfg. Co., in Cincinnati, as designing engineer. Prior to making this connection, he acted as general manager of the Nott Heater Co., located at Mount Healthy, Ohio.

George H. Robinson is now acting in the capacity of experimental engineer for the Durant Motor Co. of Michigan, in Detroit. He formerly was assistant chief engineer of the Durant Motor Co. of New Jersey, in Elizabeth, N. J.

George W. Sawyer, affiliated with the Sinclair Refining Co., New York City, has been advanced from motor-vehicle supervisor, located at Philadelphia, to superintendent of the Portsmouth Terminal, in Virginia.

Maurice A. Singer, formerly research engineer in the mechanical development department of the Bakelite Corp., at Bloomfield, N. J., has joined the Bendix Brake Co. in South Bend, Ind.

Alfred C. Smith, until lately body engineer for the Philips Custom Body Co., of Warren, Ohio, has resigned this position to engage in similar duties for the Studebaker Corp. of America, at South Bend.

George N. Somerville was recently appointed chief engineer of the Atlas-Imperial Diesel Engine Co., in Oakland, Calif. Previous to his promotion, Mr. Somerville was manager and engineer of the industrial division.

L. F. Southwick recently made a connection with the Godward Gas Generator, Inc., in New York City, as assistant to the general manager. He formerly was engineer for the Vacuum Oil Co., also of New York City.

John Squires, until lately managing director of the Chrysler Co., M.B.H., with headquarters at Berlin-Johannisthall, Germany, has become affiliated with the Fairchild Aviation Corp., in New York City.

C. E. Stryker lately resigned as instructor in the Western College of Aeronautics, Los Angeles, to become associated with William J. Waterhouse, a consulting aeronautical engineer of the same city.

W. K. Swigert recently became affiliated with the Wright Aeronautical Corp., at Paterson, N. J., where he will take charge of the St. Louis Gipsy engine plant. He formerly held the position of production manager of the Stutz Motor Car Co. of America, Inc., at Indianapolis.

J. E. Tom is no longer chief engineer of the Matthews Engineering Co., of Sandusky, Ohio, having relinquished this post to become experimental engineer for the Hercules Motors Corp., at Canton, Ohio.

A. J. Van Wagner, formerly sales engineer for the Vacuum Oil Co., at Detroit, now holds the position of sales engineer for the Tide Water Oil Co., New York City. His headquarters will be in Detroit.

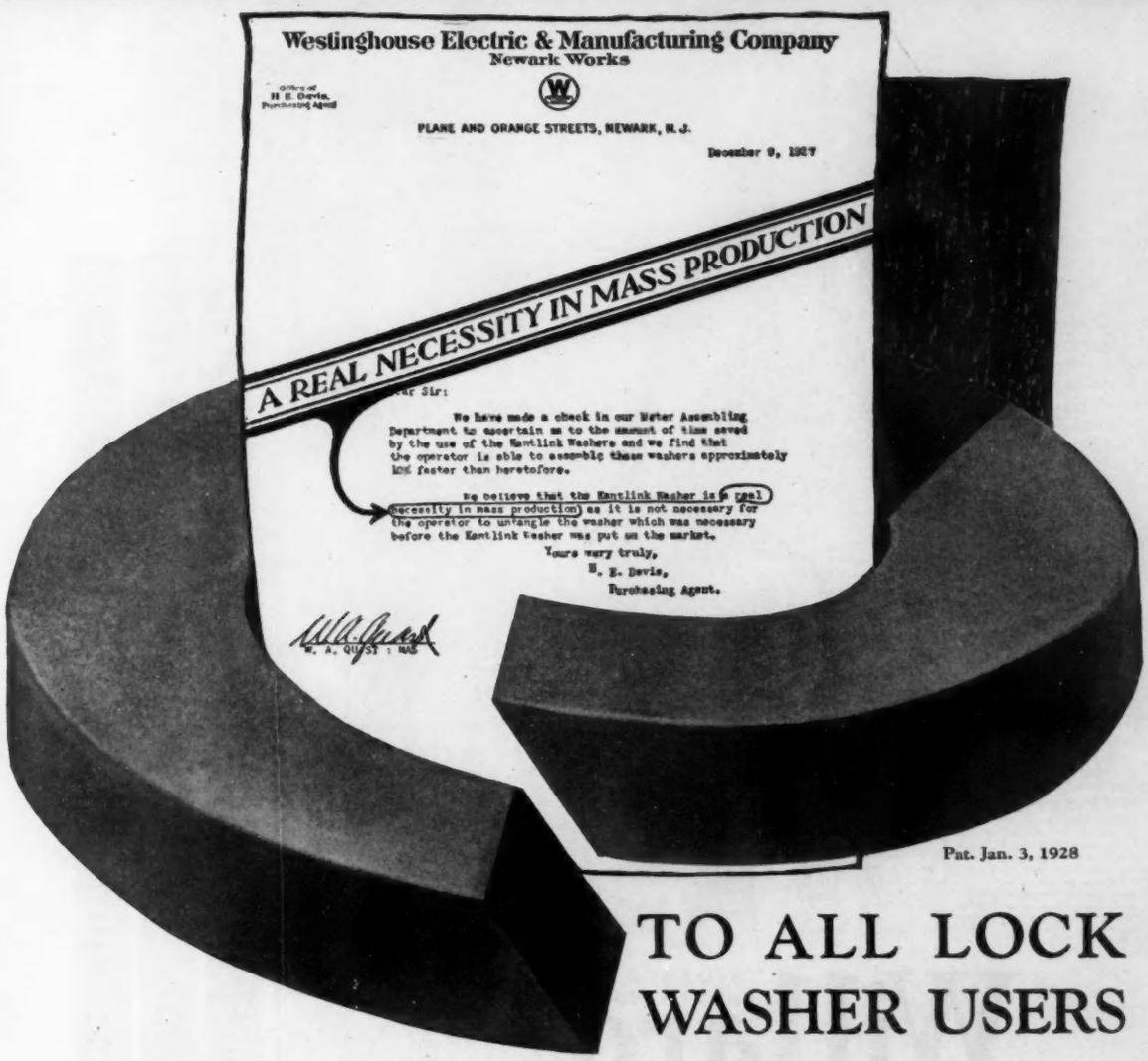
Karl F. Walker lately severed his connection with the Carter Carburetor Corp., of St. Louis, for which he acted as manager of the Detroit district, to join the engineering department of the Motor Wheel Corp., at Lansing, Mich.

Edward Wallace, until recently staff engineer of the Glenn L. Martin Co., now located at Baltimore, has been appointed staff and research engineer of the Great Lakes Aircraft Corp., at Cleveland.

A. R. Weigel recently assumed the presidency of the Barnard & Leas Mfg. Co., in Moline, Ill. He formerly acted as chief engineer and production manager of the Velie Motors Corp., also of Moline.

Edward Woydt recently left the service of the White Motor Co., of Cleveland, Ohio, for which he acted as mechanical engineer, to take up his new duties of aircraft designing engineer with the Continental Motors Corp., of Detroit.

F. R. Young has become identified with the service department of the Eclipse Machine Co., of Elmira Heights, N. Y., his headquarters to be at East Orange, N. J. Prior to making this connection, he was a member of the engineering staff of the American Chain Co., Inc., at Bridgeport, Conn.


Westinghouse Electric & Manufacturing Company
Newark Works
PLANE AND ORANGE STREETS, NEWARK, N.J.
December 9, 1927
A REAL NECESSITY IN MASS PRODUCTION
We have made a check in our Meter Assembling Department to ascertain as to the amount of time saved by the use of the Kantlink Washers and we find that the operator is able to assemble these washers approximately 10% faster than heretofore.
We believe that the Kantlink Washer is a real necessity in mass production as it is not necessary for the operator to untangle the washer which was necessary before the Kantlink Washer was put on the market.
Yours very truly,
H. E. Davis,
Purchasing Agent.
Pat. Jan. 3, 1928

TO ALL LOCK WASHER USERS

Westinghouse made tests—read what they say.

"We have made a check in our Meter Assembling Department to ascertain as to the amount of time saved by the use of the Kantlink Washers and we find that the operator is able to assemble these washers approximately 10% faster than heretofore.

"We believe that the Kantlink Washer is a real necessity in mass productions, as it is not necessary for the operator to untangle the washer which was necessary before the Kantlink Washer was put on the market."

You can save money also.

Many manufacturers save enough time by using Kantlinks to more than pay their entire lock washer cost.

Kantlinks do not tangle—they do not rust—and they have greater holding power.

Let us send you a trial order for a test in your own plant. Write today to any one of the manufacturers listed below.

Made and sold under license by the Kantlink Manufacturers:

The American Nut & Bolt Fastener Co.
Pittsburgh, Pennsylvania

The Mansfield Lock Washer Co.
Mansfield, Ohio

The National Lock Washer Co.
Newark, New Jersey

The Positive Lock Washer Co.
Newark, New Jersey

The Reliance Manufacturing Co.
Massillon, Ohio

3012-3008

KANTLINK TRADE MARK SPRING LOCK WASHERS

DO NOT TANGLE DO NOT RUST

THEY PAY THEIR ENTIRE COST IN TIME SAVED - SOMETIMES EVEN MORE

THE SATURDAY EVENING POST

You replace a smashed gasoline tank with another of the same size. Correct battery size is even more important . . .

No guess work in battery buying

. . when you consult this new guide

Batteries always have had *"size"* just like shoes and hats; but car owners never thought much about *electrical* size until they began to run up big mileages.

To take guesswork and disappointment out of battery buying, Willard has compiled a simple chart. It assures you that the battery you purchase has sufficient *electrical size* to do a satisfactory job in your car.

On this chart, beside the name of your car, is the "size" of the battery automobile engineers recommend for satisfactory and economical operation.

Not only is this "size" given in inches and number of plates . . . but an *electrical size* which stands for active electricity producing material is also shown.

You're sure . . . dead sure . . . that the battery the Willard dealer offers you will do a satisfactory job in your car. You can be equally sure that the extra margin of built-in quality in a Willard Battery will give you more for your money.

Another point to remember . . . wherever you drive your car there will always be a Willard Battery Man to give your Willard Battery the proper care and attention.

THE WILLARD *Thread-Rubber Battery* For every normal condition of driving, you will receive satisfactory service and big value with a Wood-Insulated Willard Battery. On the other hand, if your driving program calls for high mileages on constant operation of your car for a good part of each day, it will pay you to consider the Thread-Rubber type which Willard builds to meet specific conditions of heavy duty and abnormal mileage.

With this type you can expect a long term of uninterrupted service and useful life under the very heaviest driving conditions—also complete freedom from re-insulation expense; for Willard Thread-Rubber Insulation will last until you wear out the plates in the battery.

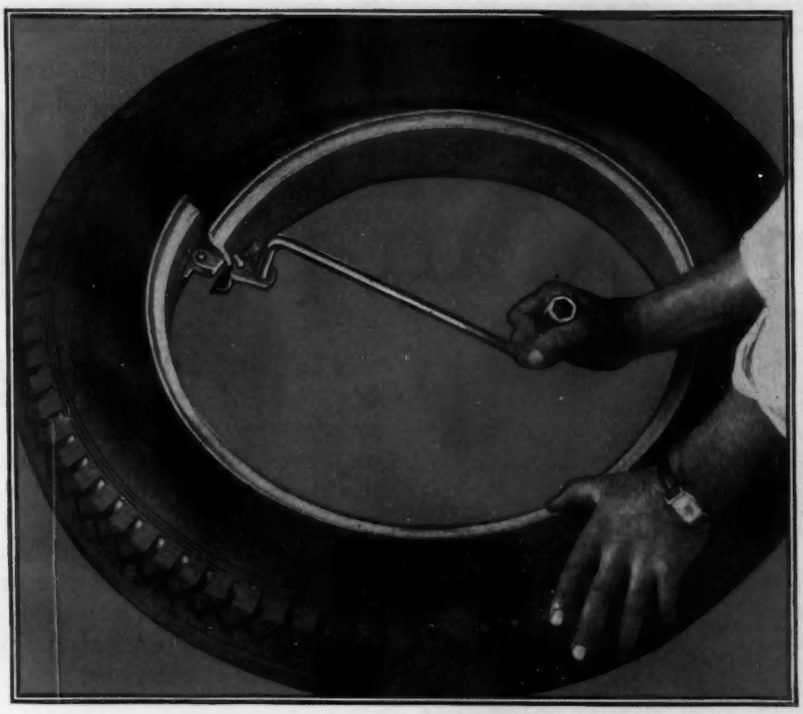
STORAGE BATTERIES

Willard

Saturday Evening Post 3,000,000
Collier's 1,645,000
Farm Papers 6,204,813

THIS SERIES OF ADVERTISEMENTS *is driving home the importance of* ELECTRICAL SIZE . .

Willard Advertising to millions of car owners recommends choosing a battery of the same *electrical size* as specified by automobile engineers for original equipment. The Willard Chart of Battery Sizes for All Cars helps the Service Station tie in with the recommendation. By this combination of advertising and merchandising an important step is made toward maintaining the electrical performance of the car you build or sell.



A twist of the wrist—an easy turn of the tool and the ClevWeld 25 Rim collapses. The tire comes off easily without prying, hammering or using tire irons. Goes back on and is locked in place just as easily. The ClevWeld 25 Rim is always free from distortion. Springs back into its original shape without pressure. Ends always meet perfectly. Casings can't be cut by rim ends.

THIS YEAR 5,000,000 TIRES WILL BE EASIER TO CHANGE BECAUSE OF THE

CLEV 25 WELD

COLLAPSIBLE RIM

CAR MANUFACTURERS—ever alert for new conveniences to offer their customers—have built a tremendous success for the makers of the ClevWeld 25 Rim.

So eagerly have they taken to this new, easily handled rim that this year it will be standard equipment on a million and a quarter new cars and the factory has been forced to 24-hour-a-day production to meet the demand.

No other rim makes tire changing so easy. No other rim is so thoroughly in keeping with the advanced engineering of today's automobiles.

And along with the rim, itself, goes a whole-hearted spirit of helpfulness and co-operation keenly appreciated by the makers of automobiles.

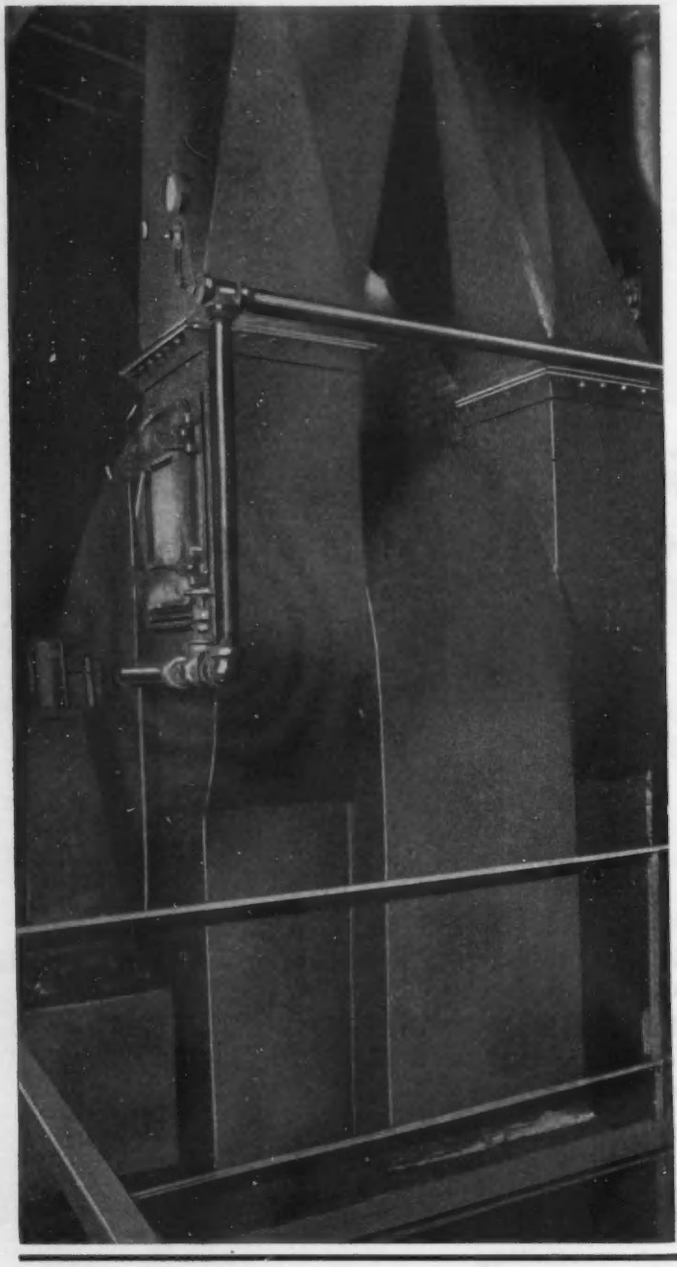
THE CLEVELAND WELDING COMPANY · *Cleveland, Ohio*
Detroit Office: 418 Stephenson Building

ClevWeld 25 Rim now standard equipment on these cars

Chandler	Graham-Paige	Nash
Chrysler	Hudson	Oldsmobile
De Soto	Marmon	Peerless
Durant	Moon	Pierce-Arrow
Gardner		Reo

THE CLEVELAND WELDING CO.

Horse-power *depends* *on* Man-power



The efficiency of power plants, big or little, steam or gasoline, depends on the man-power of the organizations that design and build them.

"Buffalo" equipment has been "engineered" to meet the unusual as well as the commonplace requirements of the airplane and automobile manufacturer.

Aviation motors are being tested daily on Buffalo Air Dynamometers. Automobile radiators are tried under operating conditions provided by Buffalo fans.

Plants of every description, garages and hangars are heated with Buffalo Unit Heaters. Buffalo fans ventilate paint spray departments, and in the powerhouse provide draft for the boilers. Body builders use our "Lowboy" heaters for oven dryers.

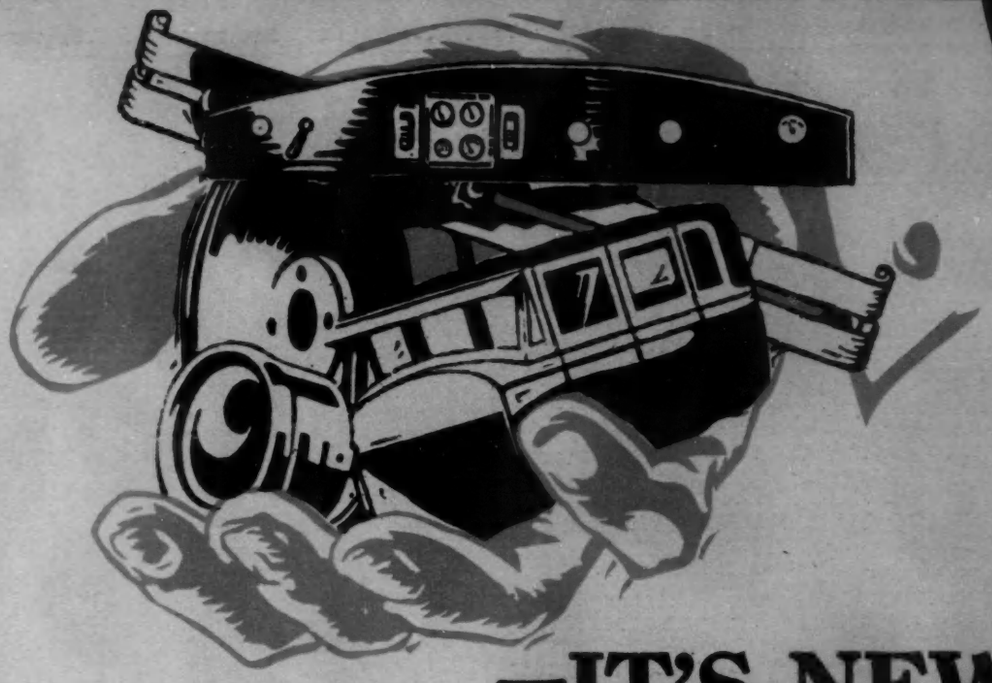
For every type of air engineering there is Buffalo equipment. Branch offices in all principal cities.

BUFFALO FORGE COMPANY
207 Mortimer St., Buffalo, N. Y.
In Canada:
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Buffalo Centrifugal Washer and Booster Fan installed in Akron rubber plant.

"Buffalo"

for Air Handling *and* Tempering Apparatus



—IT'S NEW!

IT MAKES POSSIBLE EVEN GREATER ACHIEVEMENTS IN AMERICAN INDUSTRY

HERE'S a new alloy—non-corrosive—ductile—tremendously strong—will not stain.

Its remarkable properties are creating new possibilities in every field of endeavor. It is distinctly different from present "stainless" materials.

Enduro Nirosta KA2 steel is immune to many agents which attack the straight iron-chromium alloys. It retains its sparkling finish indefinitely.

This steel is ideal for equipment or parts where corrosion must be eliminated—and for containers and machines where durable finish is much to be desired.

It will pay you to know more about Enduro KA2. Metallurgists of any of the three companies below will gladly discuss your requirements with you.

ENDURO
NIROSTA
KA2 STEEL
(KRUPP AUSTENITIC)

CENTRAL ALLOY STEEL CORP.
Massillon and Canton, Ohio

LUDLUM STEEL CO.
Watervliet, N. Y.

THE BABCOCK & WILCOX TUBE CO.
85 Liberty St., New York, N. Y.

TO AMERICA COMES THIS OUTSTANDING NEW STEEL

ENDURO NIROSTA KA2 was developed by Dr. Benno Strauss of the great Krupp works, Germany.

The companies below, licensees under the Krupp-Nirosta patents, are now producing it for American industry.

Manufacturers, ever eager for improvement, have quickly taken to this new, non-corrosive, heat-resisting steel.

You will want to know its possibilities in your own business—something of its peculiar and exclusive advantages.

Write for the booklet shown at the right. You will find it intensely interesting.

Enduro Nirosta KA2 Available in

Plates · Sheets · Bars · Strips · Forging Blanks · Shapes · Seamless Pipe and Tubing · Welding Rods · Castings · Wire.

ENDURO NIROSTA KA2 STEEL

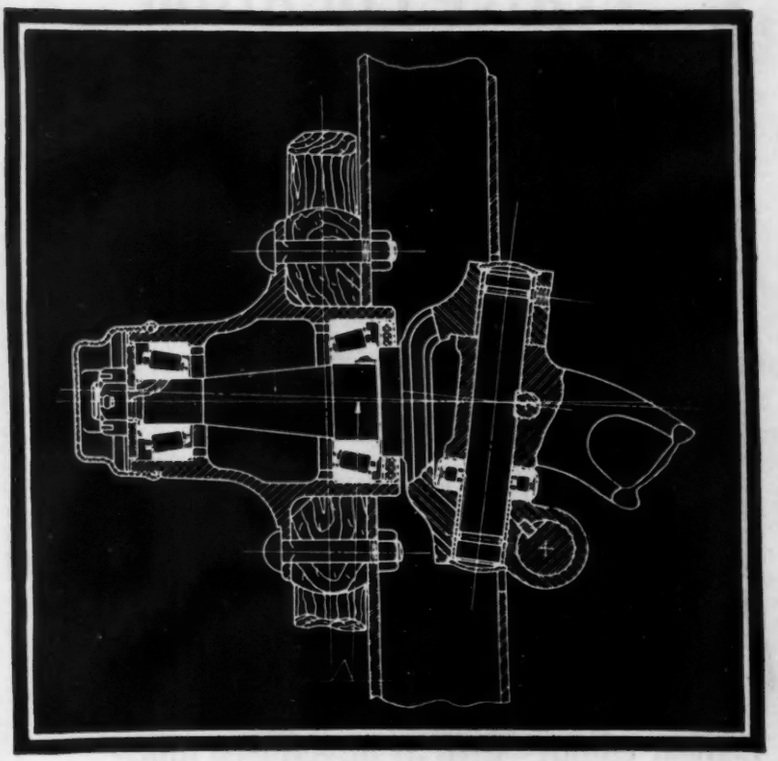
(KRUPP AUSTENITIC)

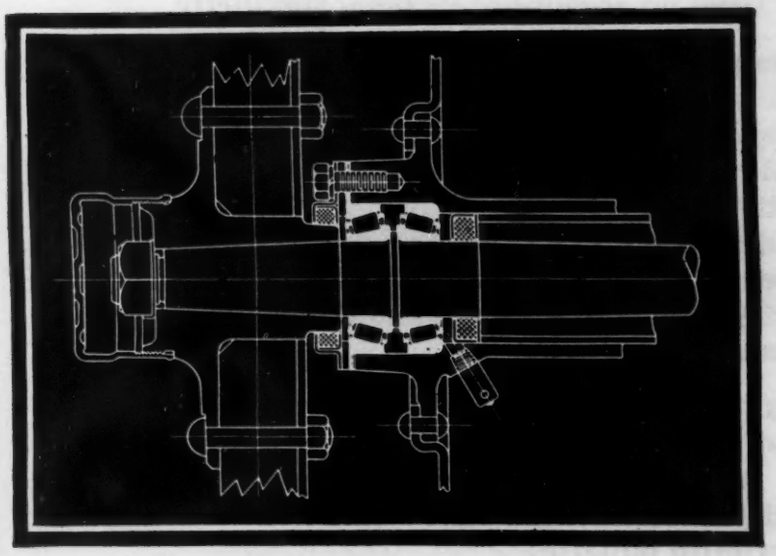
CENTRAL ALLOY STEEL CORP. *Massillon and Canton, Ohio*

LUDLUM STEEL CO. *Watervliet, N. Y.*

THE BABCOCK & WILCOX TUBE CO. *85 Liberty St., New York, N. Y.*

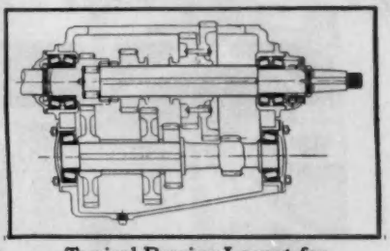
FRONT WHEELS





REAR WHEELS

and other hard service points



Typical Bearing Layout for Truck Transmission

Twisting around tortuous curves, holding the side-slant of high crowned roads from nothing to 30 miles per hour, hundreds of pounds of metal hurled forward in a few swift seconds, gaining momentum—then brought to a dead stop—it's the bearings that have to do the job.

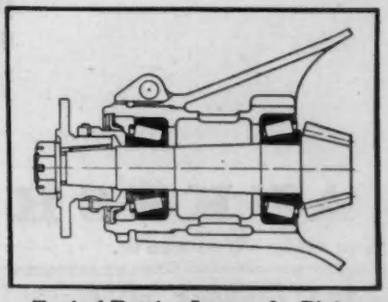
Engineering must foresee and forestall the effects of such punishment. Bearings must be good to stand such trials —**they must be more than good**— they must be designed to cope with **all** loads competently and preserve permanent alignment—**they must be Timkens!**

Timken Bearings do this as no others because of these features exclusively combined—Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS* and Timken electric steel.

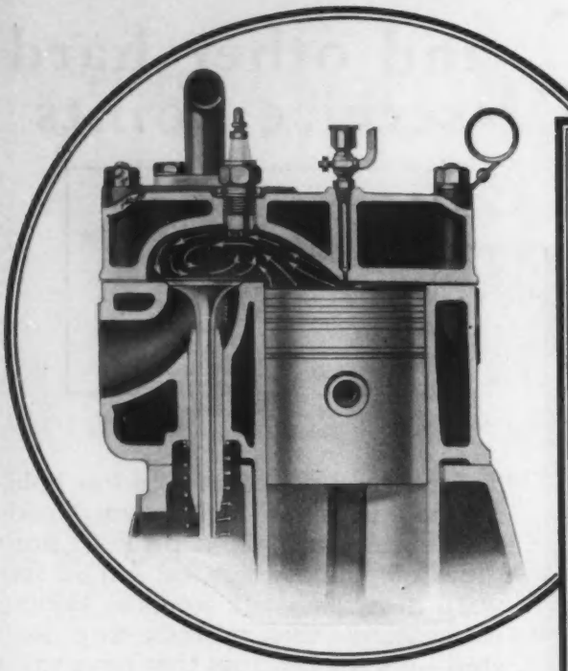
Timkens so temper the forces fighting car life that they are approved as the best engineering practice wherever wheels and shafts turn.

THE TIMKEN ROLLER BEARING CO.
CANTON, OHIO

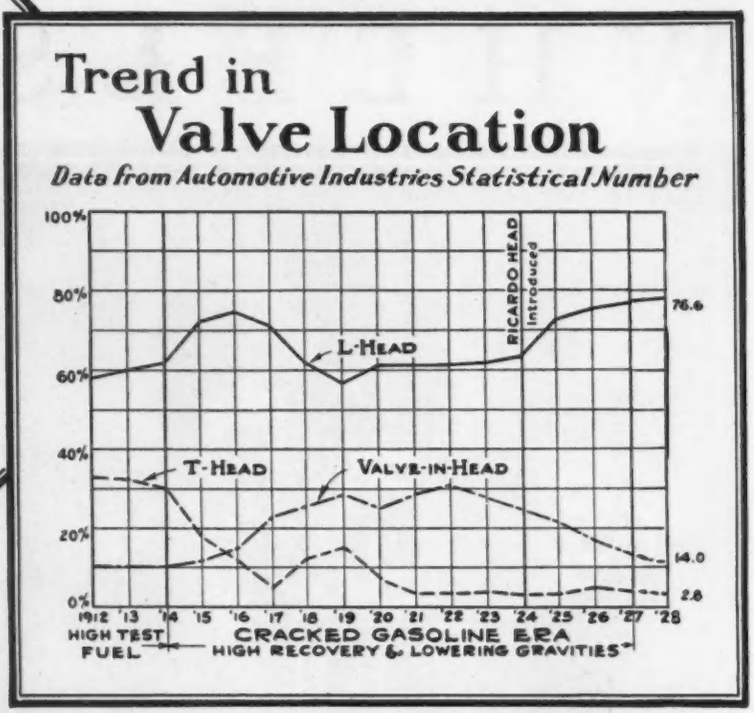
TIMKEN
Tapered
ROLLER BEARINGS



Typical Bearing Layout for Pinion



Cross-sectional view of a *Ricardo Head* Engine indicating how complete combustion is promoted by turbulence, as shown by arrows.



Simplicity wins

The L-Head engine—with its direct, well lubricated valve gear—has always had the call over other engine types on account of its great simplicity.

Waukesha Ricardo Head
L-HEAD ENGINES
THEY TAKE BETTER CARE OF THEMSELVES

A glance at the chart will show that not even DURING THE WAR did the overhead valve seriously challenge the L-Head. In 1924 the RICARDO HEAD principle was introduced. Its advantages were promptly recognized and in its basic principle it was widely adopted. L-Head engines have rapidly increased in popularity ever since—while the use of overhead valve engines has shown a correspondingly marked decrease.

Waukesha L-Head Engines, with GENUINE RICARDO combustion chambers combine high power, reliability, efficiency and long life with simplicity. Write Automotive Equipment Division for descriptive bulletin.

935

WAUKESHA MOTOR COMPANY

New York Office: 8 West 40th St. **WAUKESHA, WISCONSIN** **San Francisco: 7 Front Street**

Exclusive Builders of Heavy-Duty Internal Combustion Engines for Over Twenty Years

Our Contribution to the Industry—

Aluminum Industries, Inc.

Cincinnati, Ohio.

TO ALL ENGINEERS:

The importance of a solution to the piston problem is well recognized. The solution is a difficult matter, especially considering the fact that every increase in engine efficiency, high speeds, increased compression ratio, all contribute to the burden placed on the piston.

What was formerly our more important problem — light weight and process of casting — has been practically eliminated.

Expansion and contraction control and skirt distortion are now the more prominent. In the Permite Unitype Piston a mechanical alteration in the skirt beneath the piston pin hole ensuing from normal thermal expansion of the piston head does not distort the bearing areas of the thrust faces of the piston.

We have stepped aside from established precedents by division in the piston pin bosses. In so doing, heat transferred from the head of the piston is not direct to the thrust bearing areas but is diverted to the lower end of the piston beneath the piston pin bosses and thence to the skirt so that the skirt operating temperature has been considerably reduced.

The thrust faces of the piston skirt are suspended by two transverse aluminum alloy struts, the action of which are independent of any mechanical alteration of the piston pin boss area.

The Permite Unitype design is scientifically correct and is readily adapted as a medium of solving one of the most difficult problems that you have in Automotive Engineering.

We request you to permit us to give you a detailed explanation of this new design of piston.

Very truly yours,

ALUMINUM INDUSTRIES, Inc.

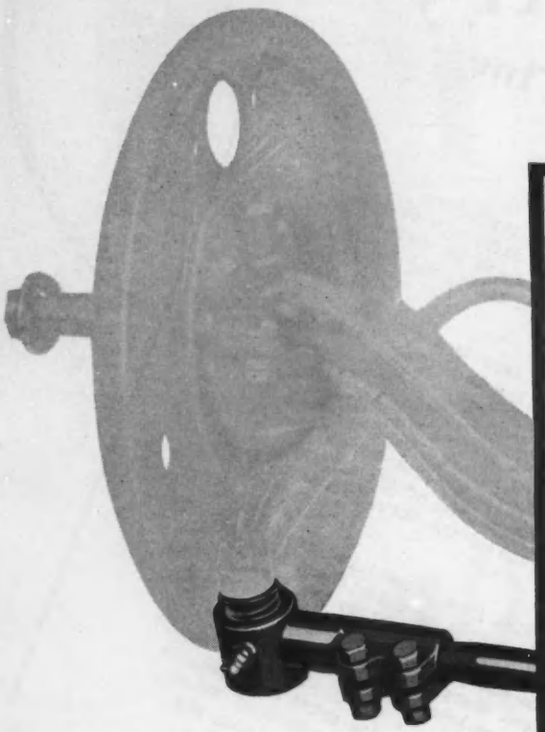
W. W. Beckman

Chief Engineer

718 Fisher Bldg., Detroit, Mich.

PERMITE UNITYPE PISTONS

These Axle Companies



COLUMBIA
EATON
SALISBURY
SHULER
TIMKEN

In addition to its use by leading axle companies, the Eccentric is now standard equipment on 36 makes of cars and trucks. A specialty in 1927, it has grown step by step with the increasing need for greater steering safety at low production cost. During the coming year 1,600,000 new Eccentrics will be used in response to *consumer demand.*

use *Eccentric*..

Thompson Eccentric Tie-Rods are made in the Detroit Plant of Thompson Products, Inc., steering linkage specialists to the industry since 1912.

1¼-in. ball Thompson Eccentric Tie-Rod Socket. Eccentric is "the ideal tie-rod" for positive safety, minimum end clearance, permanent rigidity, light weight, easy steering, ample lubrication, sealed socket, quick assembly, servicing simplicity, reasonable cost.

THOMPSON PRODUCTS, INC.

General Offices: Cleveland, Ohio, U. S. A.
Factories: CLEVELAND and DETROIT

Thompson Valves, Pistons and Pins, King, Shackle and Tie-Rod Bolts, Tappets, Tie-Rods, Drag Links, Starting Cranks and Brake-Rod Assemblies.

Thompson Eccentric Tie Rods

SHAKEPROOF LOCK WASHERS

UNDER the whip of modern production—no time to waste—the finest possible job in the shortest possible time—here is where SHAKEPROOF is solving the problems of modern industry. A modern washer with teeth that bite into the nut with a grip of steel that only applied force with a wrench can loosen.

SHAKEPROOF Lock Washers are made in a wide variety of types and sizes to fit every need of modern industry. Mail the coupon below for samples and make your own tests. SHAKEPROOF can save you time and money and assure a better job on your production line.

Type 11 External

Type 12 Internal

Type 20 Terminal

U. S. PATENTS 1,419,584; 1,604,122; 1,607,954. OTHER PATENTS PENDING. FOREIGN PATENTS.

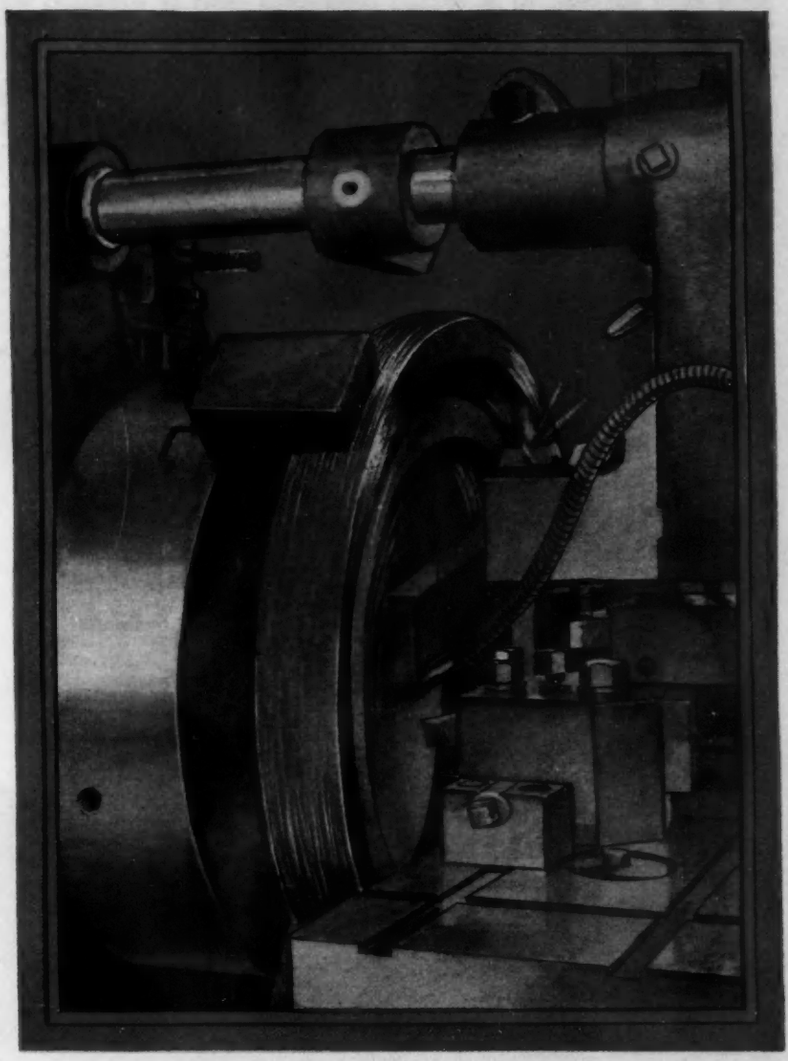
FREE SHOP TEST SAMPLES

SHAKEPROOF LOCK WASHER CO.
2507 North Keeler Ave., Chicago, Ill.
Please send me samples of

☐ Shakeproof Lock Washers to fit bolt size _____
☐ Shakeproof Locking Terminals, size _____
Firm Name _____
Address _____
Town _____ State _____
By _____

SHAKEPROOF
Lock Washer Company
{ Division of Illinois Tool Works }
2507 North Keeler Avenue **Chicago, Illinois**

REASONS WHY ILLINOIS ALLOY IS A SUPERIOR STEEL



Ease of Machining

• • • • Coming to you with an unusually clean, workmanlike appearance, Illinois Alloy Steel frequently requires *less machining*.

• • • • Its sound homogeneous structure permits a deeper cut with safety as well as an increased machine speed which results in *reduced machining time*.

• • • • Ease of machining is only one of the qualities that make Illinois Alloy a superior steel. Others are: uniform flow of metal during forging, uniformity on quenching, deep case on carburizing. Four advantages—each a good reason for *standardizing* on Illinois Alloy Steel.

• • • • Our metallurgists will gladly cooperate in solving your alloy problems.

Illinois Steel Company

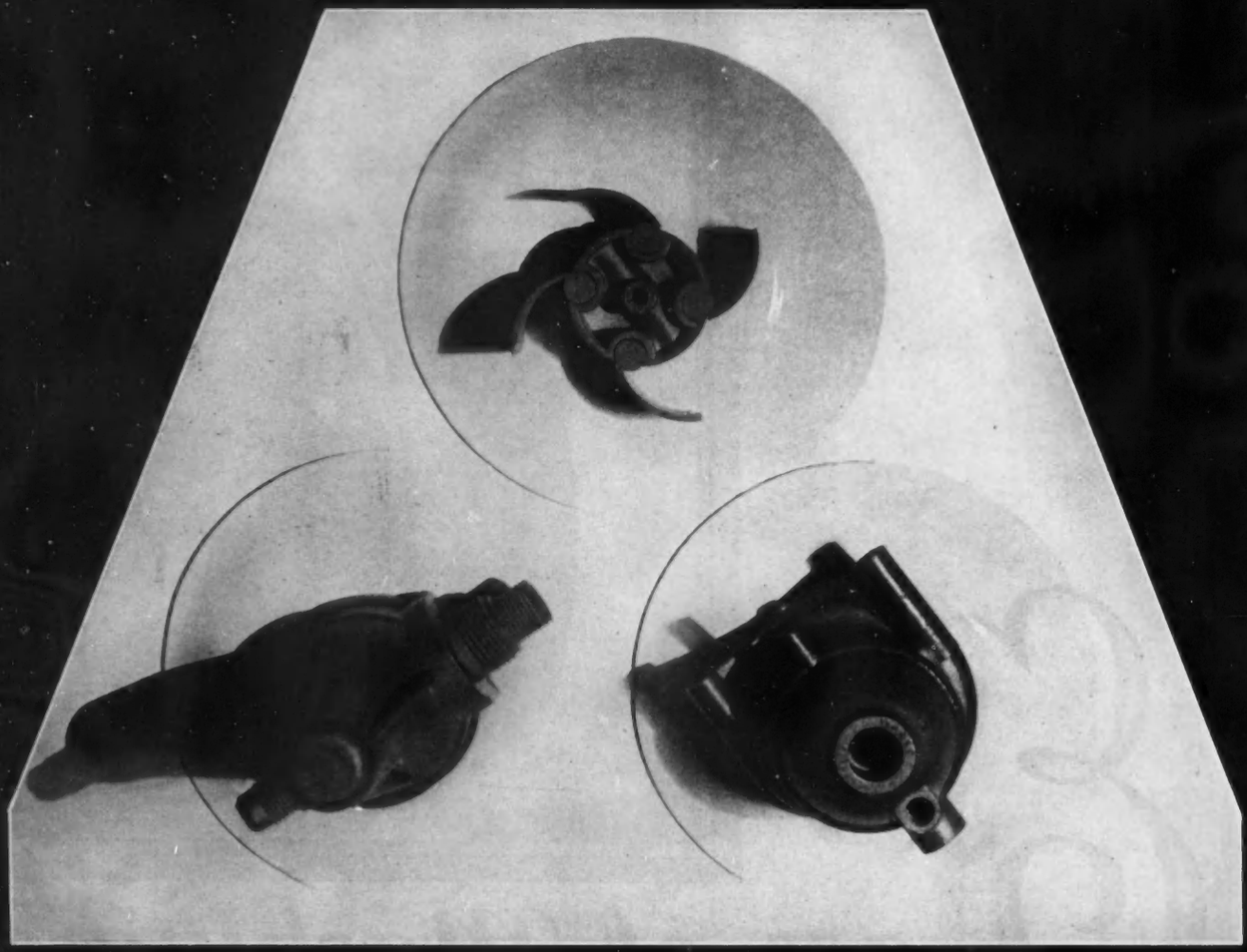
Subsidiary of United States Steel Corporation

General Offices: 208 South La Salle Street, Chicago, Illinois

ILLINOIS *Alloy* STEEL

HORSE HEAD ZINC

FOR THE DIE CASTING INDUSTRY



CASTINGS, COMPLETE WHEN CAST

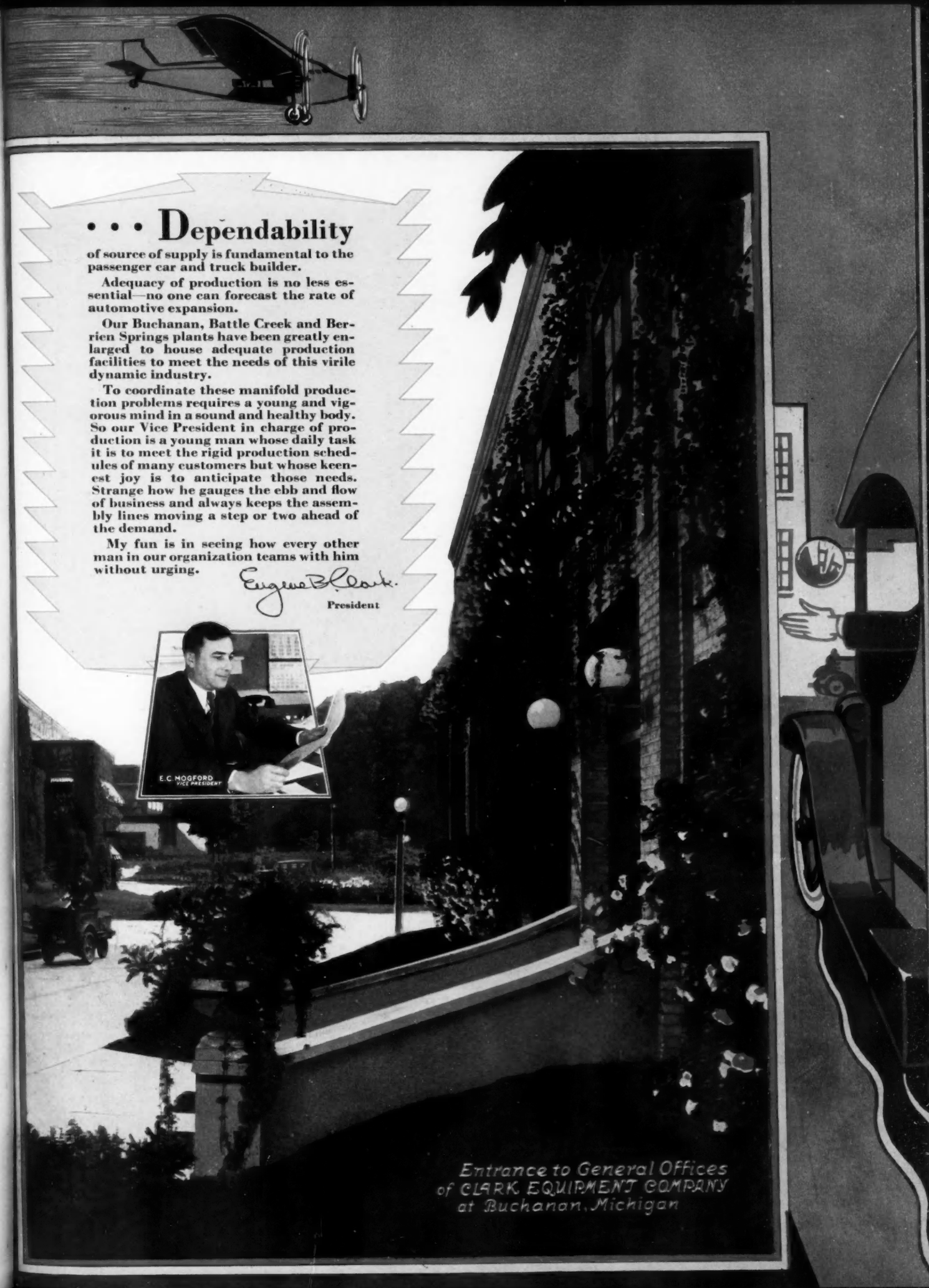
Speed of production demands castings full-grown at birth. ¶ Look at these die-castings. You see threads . . . born full-grown when the mold was opened. You see unmachined parts fitting closely into other unmachined parts . . . born with close clearances. You see perfect core holes, untouched by cutting tools . . . another birthright of die-casting. ¶ You see three zinc-base die-castings born to man's estate. *Not one ever felt the growing pains of machining.* ¶ Horse Head Zinc is the base of each. These castings are as serviceable as the die-casting process is efficient. The *uniform quality* of Horse Head Zinc assures long-life castings to the user.

New Jersey zinc

THE NEW JERSEY ZINC SALES CO.

160 FRONT STREET, NEW YORK CITY

ZINC METALS AND ALLOYS - ROLLED ZINC - ZINC PIGMENTS - SULPHURIC ACID - SPIEGELEISEN


• • • Dependability
of source of supply is fundamental to the passenger car and truck builder.
Adequacy of production is no less essential—no one can forecast the rate of automotive expansion.
Our Buchanan, Battle Creek and Berrien Springs plants have been greatly enlarged to house adequate production facilities to meet the needs of this virile dynamic industry.
To coordinate these manifold production problems requires a young and vigorous mind in a sound and healthy body. So our Vice President in charge of production is a young man whose daily task it is to meet the rigid production schedules of many customers but whose keenest joy is to anticipate those needs. Strange how he gauges the ebb and flow of business and always keeps the assembly lines moving a step or two ahead of the demand.
My fun is in seeing how every other man in our organization teams with him without urging.
Eugene B. Clark.
President
E.C. MOGFORD
VICE PRESIDENT
Entrance to General Offices
of CLARK EQUIPMENT COMPANY
at Buchanan, Michigan

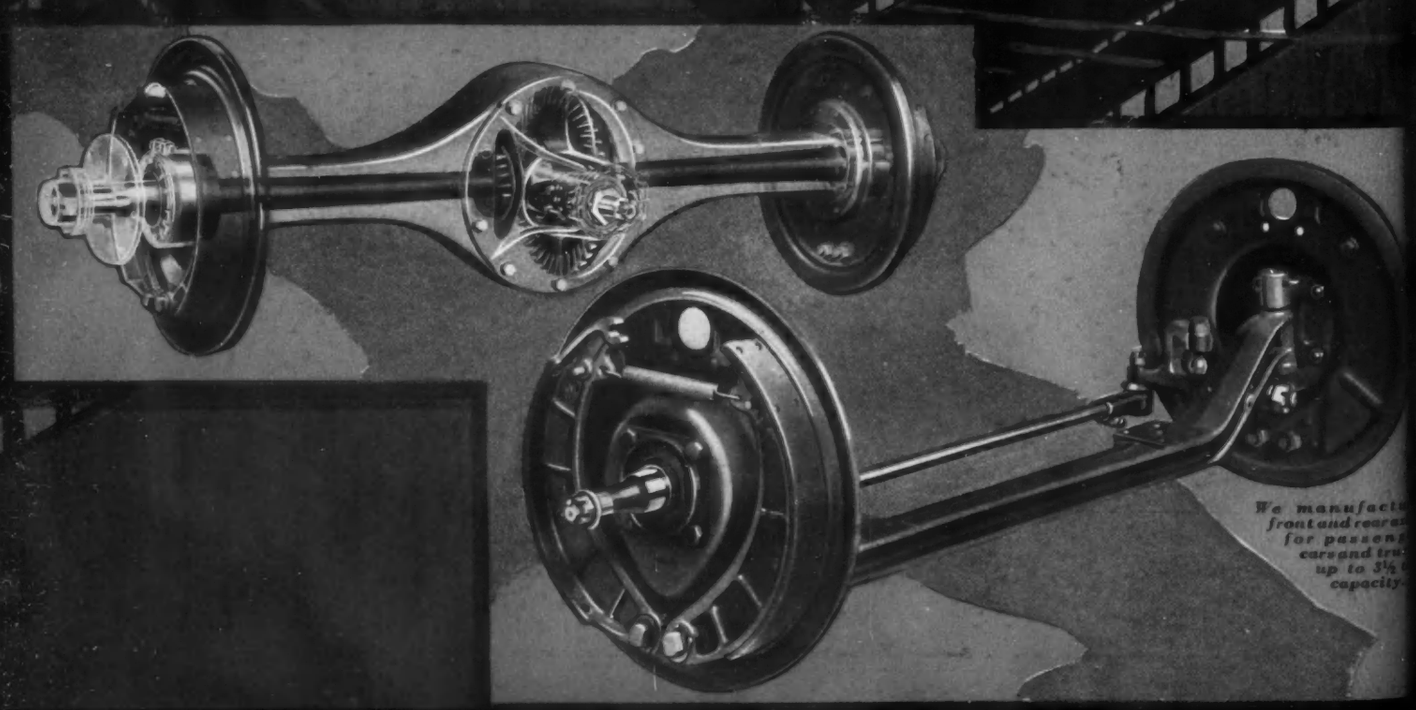
CLARK AXLES

• • • Time

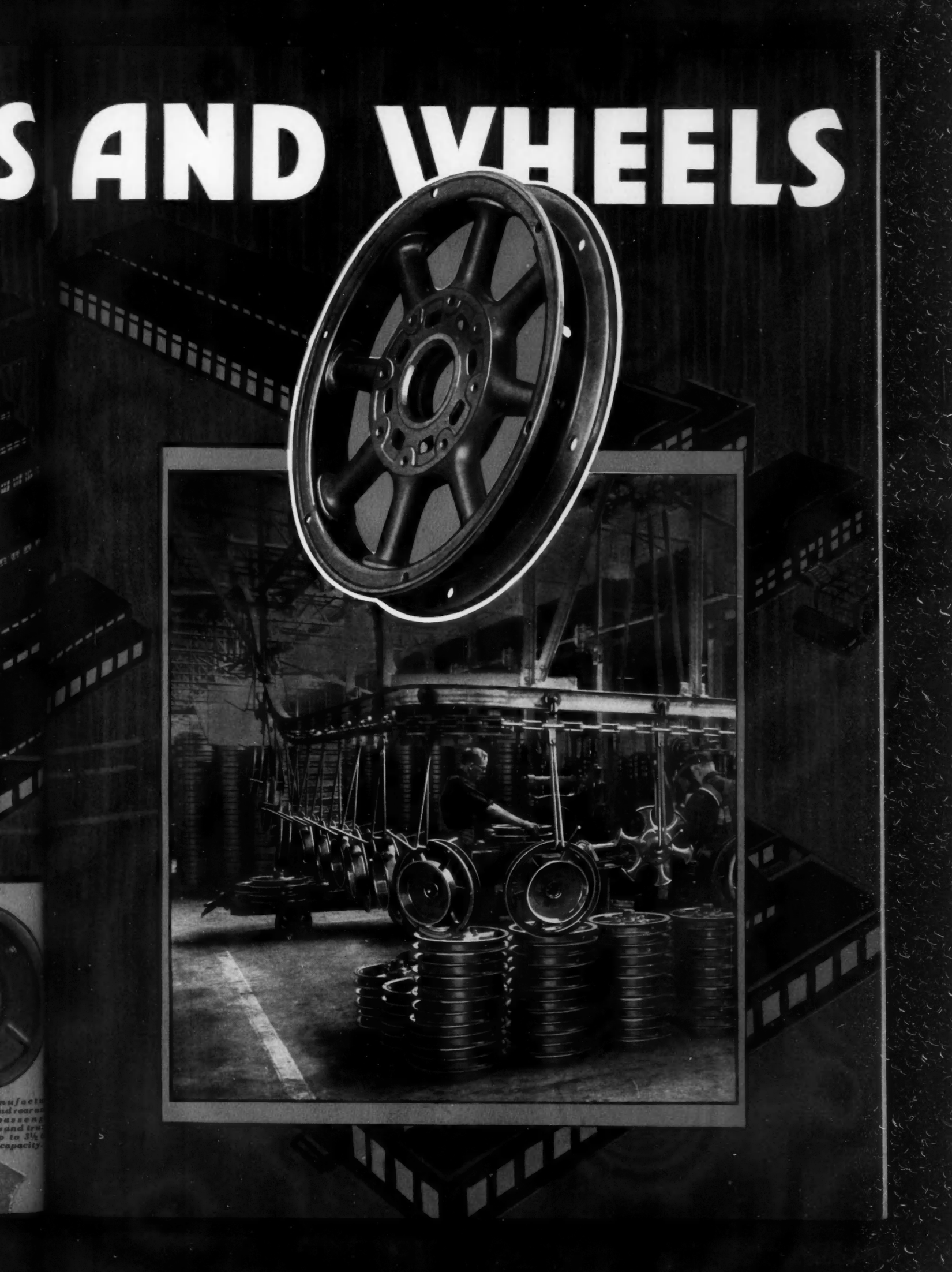
is no respecter of persons. Every seven seconds a brand new American automobile or truck leaves some assembly line. Every swing of the pendulum calls for a wheel and every fourth an axle.

Our plants run night and day to keep up with the seasonal demand of our customers' needs. That we keep our old customers and add new ones is evidence of appreciation of our product and our efforts to adequately fill their requirements.

CLARK EQUIPMENT COMPANY
Buchanan, Michigan



S AND WHEELS

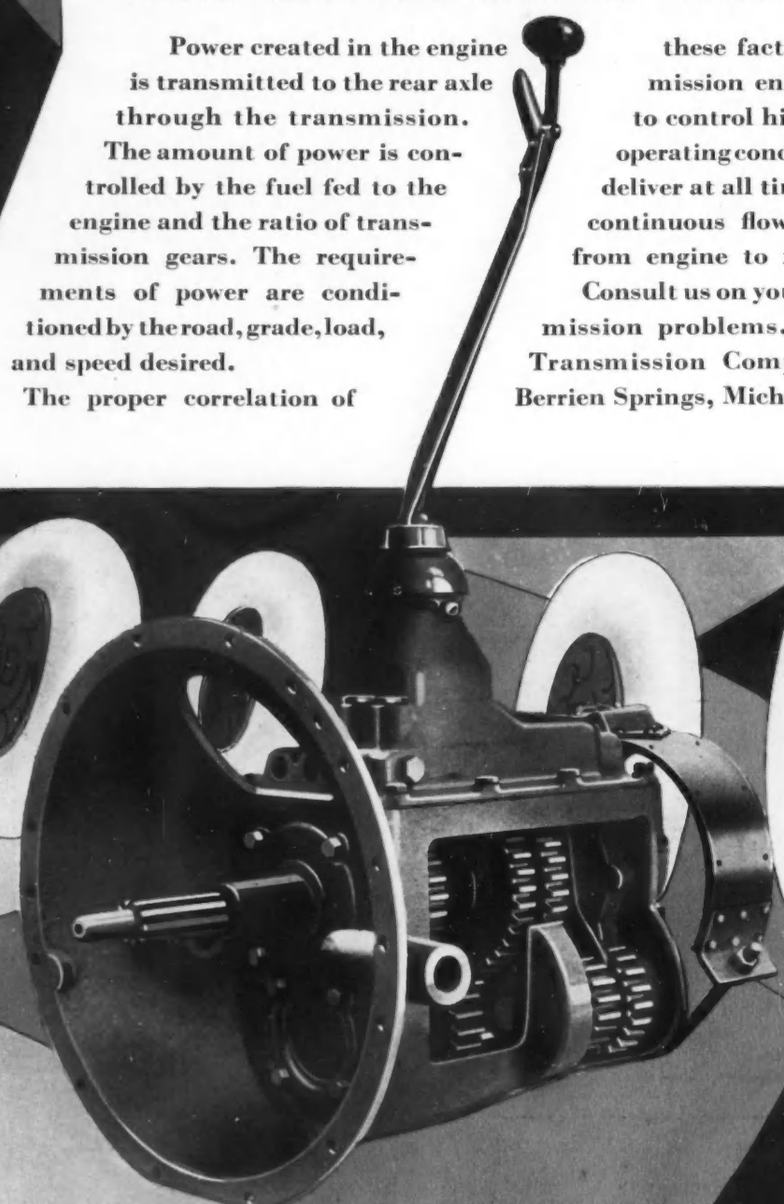


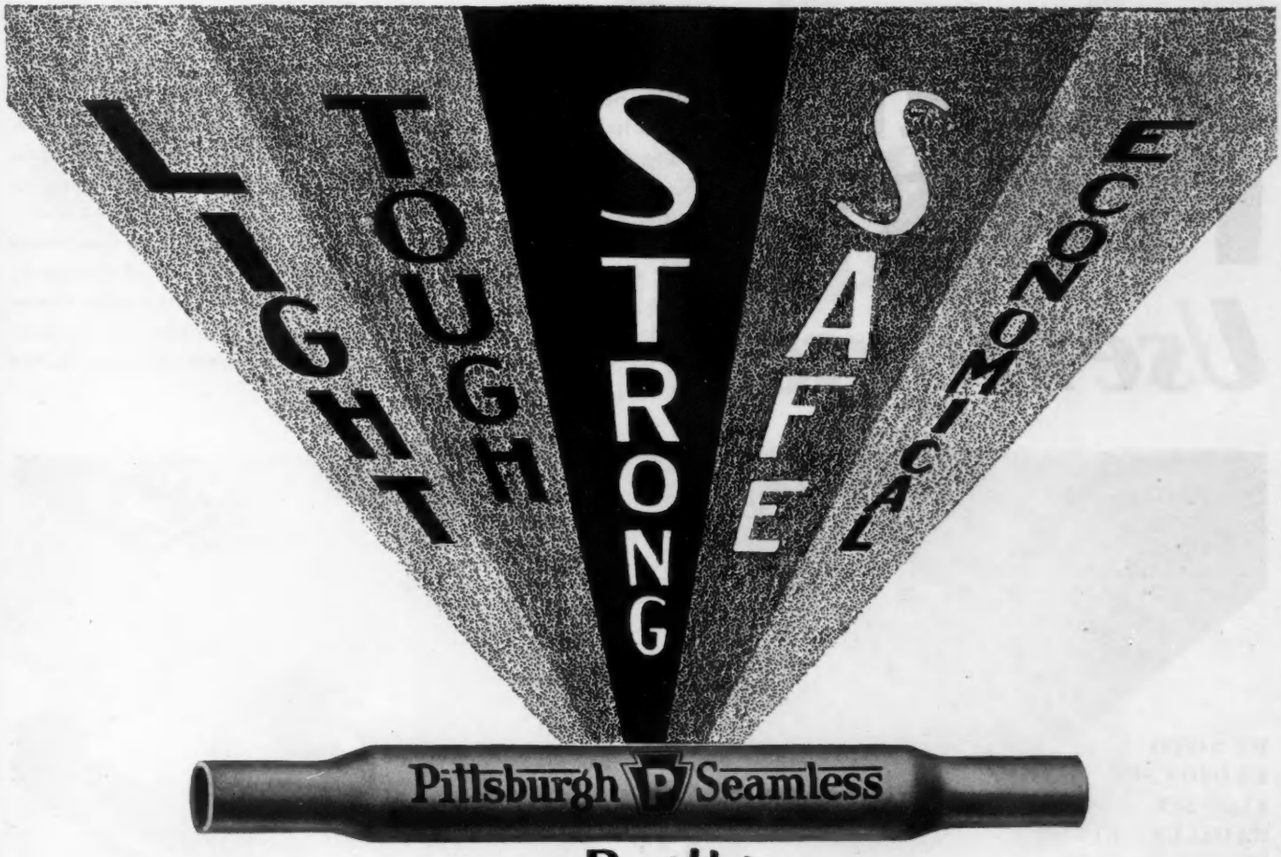
CLARK TRANSMISSIONS

• • The automotive industry has time and again accomplished what seemed to be impossible. When a prominent manufacturer announces a new car the public flocks in to see it and pronounces it "the last word in automobiles." But even as they crowd the doors the engineers are busy on new refinements and improvements so that the next car will be a little better than the best.

Power created in the engine is transmitted to the rear axle through the transmission. The amount of power is controlled by the fuel fed to the engine and the ratio of transmission gears. The requirements of power are conditioned by the road, grade, load, and speed desired.

The proper correlation of these factors in the transmission enables the driver to control his car under all operating conditions, and to deliver at all times a steady continuous flow of power from engine to rear axle. Consult us on your transmission problems. Clark Transmission Company, Berrien Springs, Michigan.





Is Being Built to Order

Most automotive manufacturers have already discovered the exceptional advantages of Pittsburgh Seamless steel formed mechanical tubing as a semi-finished product from which completed automotive parts—shaped to the finest standards—can be produced both quickly and inexpensively with a minimum of finishing.

We have long specialized in the manufacture of fine grade regular and special analysis seamless steel tubes—swaging, flanging, tapering or forming them to buyers' specifications in our Specialty Department.

Our engineers have frequently been able graphically to demonstrate the wisdom of changes from solid stock and forgings to Pittsburgh Seamless in modern automobile construction. They are available at your call without obligation.

Propeller Shafts *Torque Tubes*
Steering Columns *Wrist Pins*
Brake Rocker Shafts *Bearing Races*
Frame Cross Members
Drag Links *Axle Housing Sleeves*
Valve Rocker Shafts *Tie Rods*

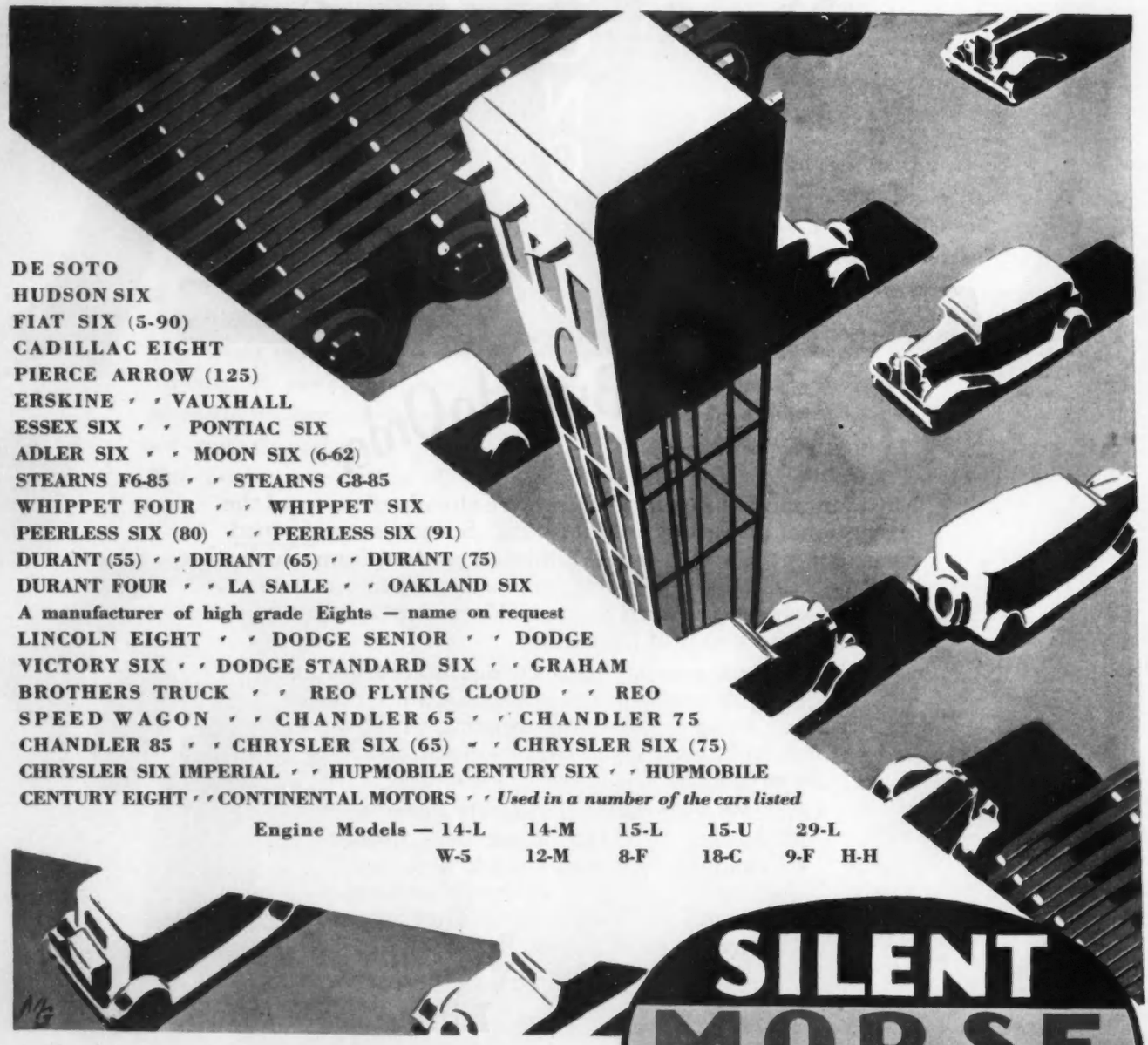
Pittsburgh Steel Products Co.
DIVISION OF
Pittsburgh Steel Co.

PITTSBURGH NEW YORK DETROIT
CHICAGO ST. LOUIS HOUSTON TULSA

Largest Manufacturers of Seamless Steel Tubes Exclusively

SAFETY FIRST! Use Morse

Sixteen years of steadily growing acceptance by the country's foremost automotive engineers indicates that Morse Genuine Silent Chains are best for front-end timing. ¶ For years, a big majority of cars using Silent Timing Chains have been Morse equipped. Every year has shown a steady increase in application, from small inexpensive cars, to the most costly custom-built limousines. ¶ Years of engineering experience and specialization have resulted in correctness of design — in quietness and dependability of operation — that have made Morse Genuine Silent Timing Chains the standard of the industry. ¶ Read the list of manufacturers using Morse Silent Chains as standard equipment.



DE SOTO
HUDSON SIX
FIAT SIX (5-90)
CADILLAC EIGHT
PIERCE ARROW (125)
ERSKINE • • VAUXHALL
ESSEX SIX • • PONTIAC SIX
ADLER SIX • • MOON SIX (6-62)
STEARNS F6-85 • • STEARNS G8-85
WHIPPET FOUR • • WHIPPET SIX
PEERLESS SIX (80) • • PEERLESS SIX (91)
DURANT (55) • • DURANT (65) • • DURANT (75)
DURANT FOUR • • LA SALLE • • OAKLAND SIX
A manufacturer of high grade Eights — name on request
LINCOLN EIGHT • • DODGE SENIOR • • DODGE
VICTORY SIX • • DODGE STANDARD SIX • • GRAHAM
BROTHERS TRUCK • • REO FLYING CLOUD • • REO
SPEED WAGON • • CHANDLER 65 • • CHANDLER 75
CHANDLER 85 • • CHRYSLER SIX (65) • • CHRYSLER SIX (75)
CHRYSLER SIX IMPERIAL • • HUPMOBILE CENTURY SIX • • HUPMOBILE
CENTURY EIGHT • • CONTINENTAL MOTORS • • *Used in a number of the cars listed*

Engine Models — 14-L 14-M 15-L 15-U 29-L
W-5 12-M 8-F 18-C 9-F H-H

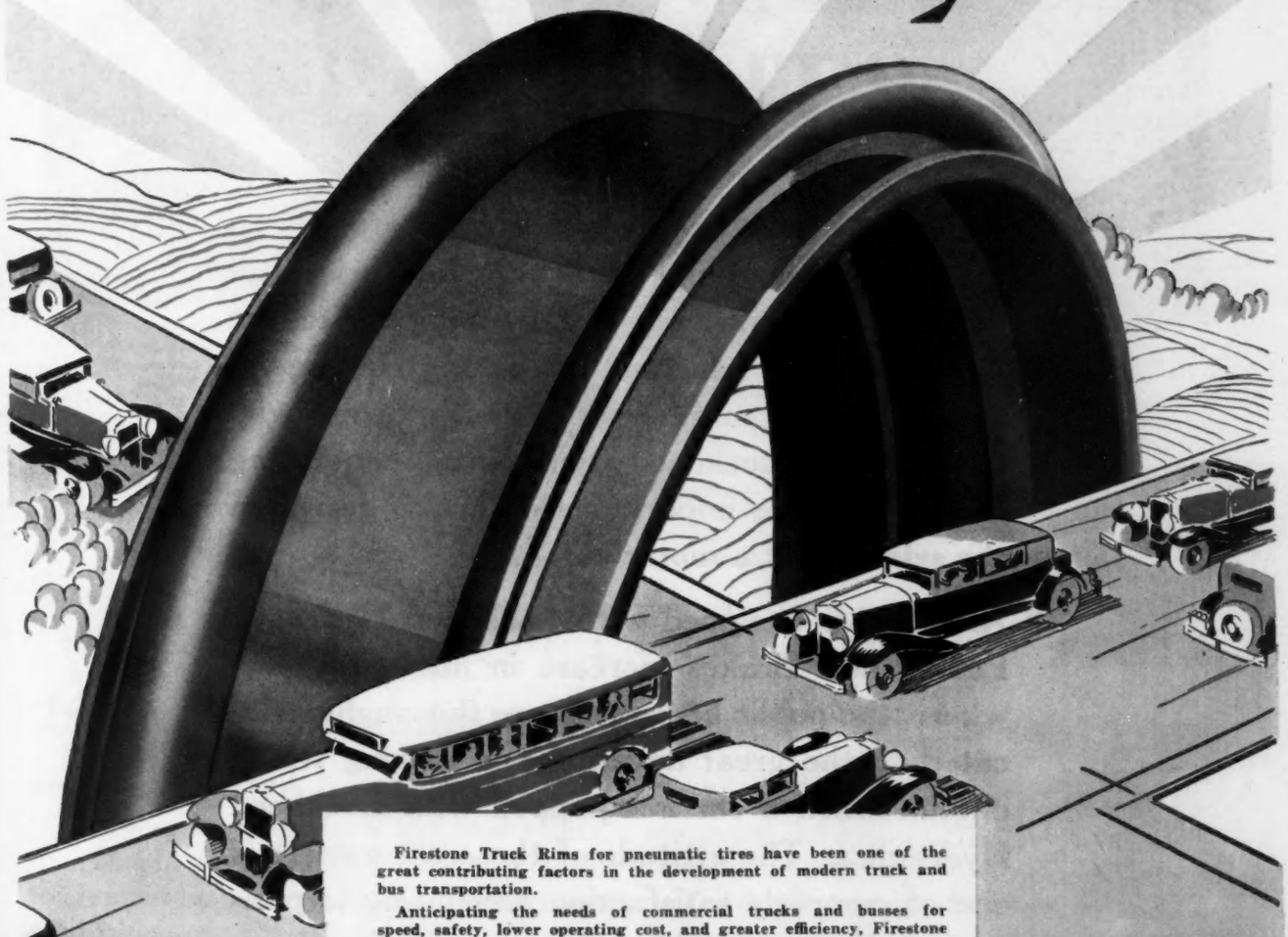
SILENT MORSE PRECISION PRODUCTS CHAINS

MORSE CHAIN CO.

Main Office and Works
ITHACA, NEW YORK

Sales and Engineering Office
DETROIT, MICHIGAN

On The Wheels of Commerce and Industry



Firestone Truck Rims for pneumatic tires have been one of the great contributing factors in the development of modern truck and bus transportation.

Anticipating the needs of commercial trucks and busses for speed, safety, lower operating cost, and greater efficiency, Firestone has always offered the industry Rims of correct design for all requirements.

Whether your choice is wood, wire, disc, steel spoke, or cast wheels, your greatest protection is to specify Firestone Rims.

Firestone's long experience, tremendous resources, and straight-line production will save you time and money.

Firestone RIMS

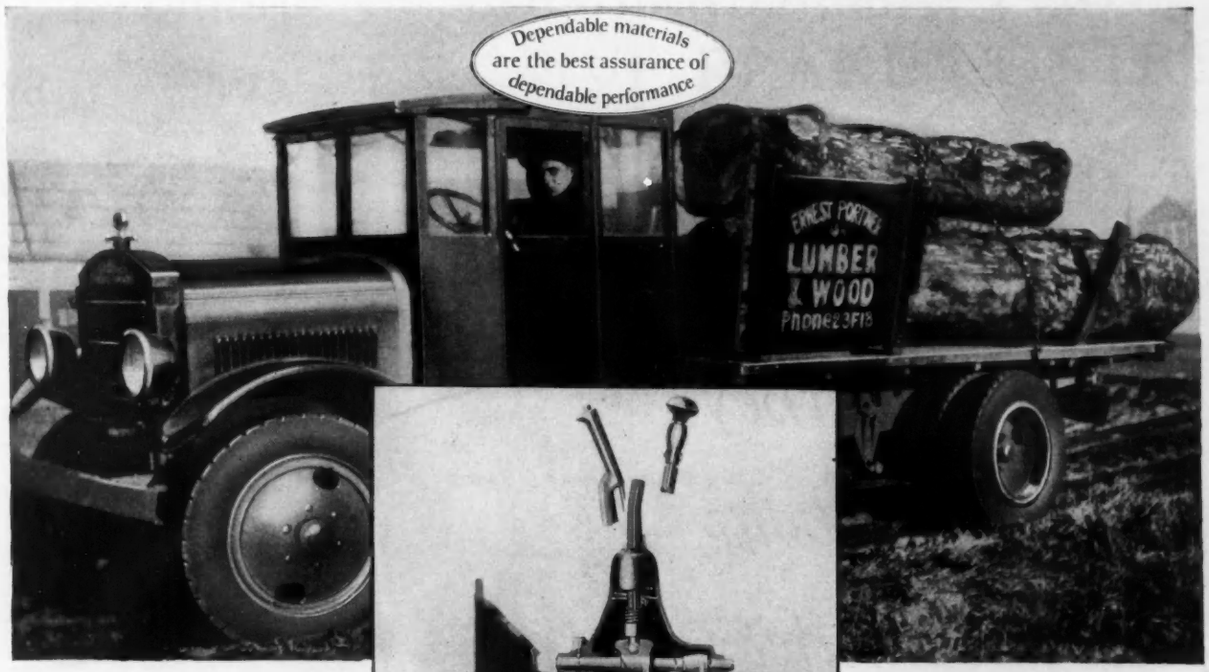
Every day,
in automobile designing,
"Good Enough" is giving way to
"The Best"

TODAY automobile manufacturers—even those who build to a very low price—all recognize the necessity of keeping up to the minute. In the selection of braking equipment, the increasing number of manufacturers who have adopted Lockheed Hydraulics is convincing evidence of the importance of brake design in the selection of a motor car.

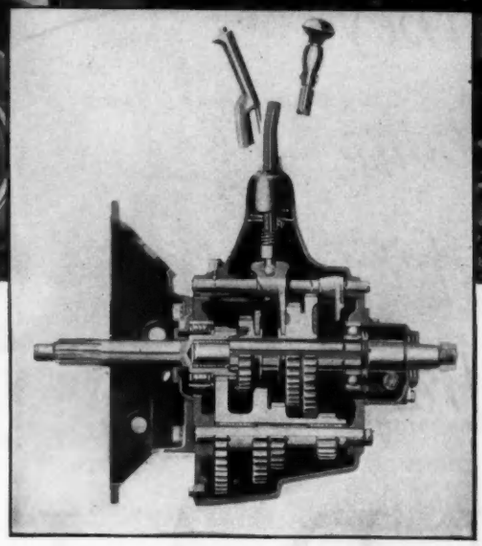
As the cars equipped with Lockheed Hydraulic Four-Wheel Brakes increase in number everywhere, the public becomes more thoroughly educated to the great advantage in driving which obtains when a car is equipped with Lockheed Hydraulics. The attitude of these car owners is one of complete satisfaction amounting to positive enthusiasm. This, of course, is having a direct reaction upon car sales and through car sales upon car manufacturers.

LOCKHEED HYDRAULIC
Four BRAKES *Wheel*

HYDRAULIC BRAKE COMPANY, DETROIT, MICHIGAN, U. S. A.



Above: *Reo heavy duty truck using Warner Gear Co. Nickel Steel gears and shafts in transmission.*



Left: *Heavy duty gear transmission for Reo trucks mfd. by WARNER GEAR CO., Muncie, Ind. This transmission uses 3½% Nickel Alloy Steel gears and shafts.*

WARNER 3½% *Nickel Steel Gears*

Insure Dependability in REO Trucks and Speedwagons

TO withstand the severe, day-in-and-day-out service which Reo heavy duty trucks and Speedwagons encounter, their transmissions must be unquestionably dependable... so the Warner Gear Co. uses 3½% Nickel Alloy Steel gears and shafts.

By using Nickel Alloy Steel, warpage and distortion are reduced to a minimum, since lower heat treating temperatures are permitted. Furthermore, carbon penetration during the carbonization period is more uniform, and greater toughness is secured in both case and core. The increased hardness and toughness afforded by the use of Nickel Alloy Steel transmission parts assure adequate resistance to the wear and impact encountered when roads are rough and loads are heavy.

Nickel
FOR ALLOY STEEL

The fact that practically all American and European manufacturers of airplane engines have adopted Nickel Steel for highly stressed parts particularly where weight must be pared to a minimum, furnishes impressive evidence of the uniform, dependable mechanical properties of Nickel Alloy Steels.

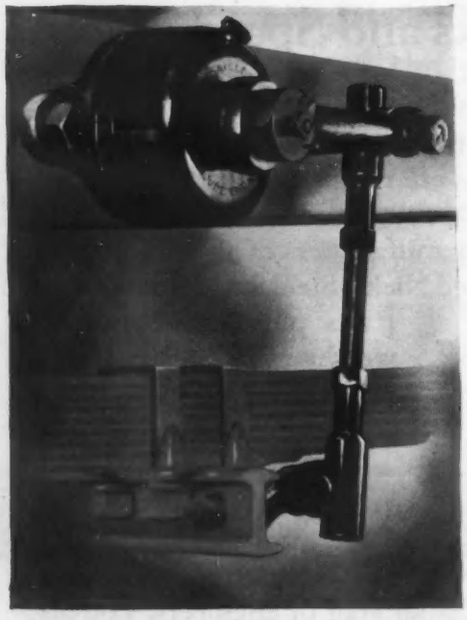
Information on the properties and applications of Nickel Alloy Steels will be gladly furnished by our staff of engineers. You are invited to write for additional data.

SEND FOR "BUYERS' GUIDE TO NICKEL ALLOY STEEL PRODUCTS"

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

...and they learned about Speed with Safety from

HOUDAILLE



FOR THE SMOOTHEST RIDE OVER THE ROUGHEST ROADS TO ANYWHERE

AUTOMOBILE engineers are not only building speed into their cars but making it safe to enjoy it. The supreme riding comfort and positive action of Houdaille hydraulic double acting shock absorbers are important contributions to speed with safety. Houdaille's twenty-seven years of pioneering have demonstrated their worth.

Every Houdaille feature . . . its double or balanced piston eliminating side thrust wear, its precision workmanship, its patented air vents and leak proof replenishing chamber, its simple adjustment . . . all combine to make Houdaille hydraulic double acting shock absorbers the world's standard of comparison.

Houdaille shock absorbers have been made standard equipment by the engineers of Lincoln, Pierce-Arrow, Cunningham, Stearns-Knight, Jordan, Ford, Nash Advanced Six, Chrysler Imperial, Studebaker President, Graham-Paige, and many European cars. No manufacturer, having made Houdailles standard equipment, has ever given them up. No greater tribute could be paid.

Houdaille Engineers are specialists on making cars ride smoothly. Their experience is at your command.

HOUDE ENGINEERING CORPORATION, BUFFALO, N.Y.

HOUDAILLE

HYDRAULIC DOUBLE-ACTING SHOCK ABSORBERS

Tonnage Capacity and Hauling Power matched by EFFECTIVE BRAKE CONTROL

The Beaver Valley Service Company, which operates an extensive freight and express service, uses tractor and trailer equipment to haul merchandise between the main warehouses at Pittsburgh and New Brighton.

The original haulage unit comprised a four cylinder tractor and an eight ton semi-trailer (with Westinghouse Air Brakes on the trailer and rear wheels of the tractor.) But, as business increased, additional tonnage capacity was needed.

This was accomplished by using two ten-ton semi-trailers and a high powered six cylinder tractor, to maintain the same running time as before.

The heavy tonnage (pay load of 20 tons) and high power (100 horse power) are adequately controlled by Westinghouse Air Brakes, on both trailers and on all four wheels of the tractor.

The Beaver Valley Service Company now operates three white tractors and nine Lapeer semi-trailers equipped with Westinghouse Air Brakes—the modern safeguard for heavy highway transportation.

WESTINGHOUSE
AUTOMOTIVE AIR BRAKES

WESTINGHOUSE AIR BRAKE COMPANY

Automotive Brake Division **Pittsburgh, Pa.**

Europe's Famous Designers ASSIST IN HAYES Creations

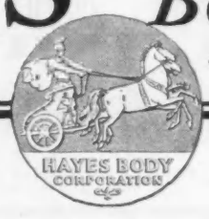
WITH the resources, experience, and equipment of the Hayes Body Corporation at their command, Hayes master craftsmen are facilitated in their task of creating the finest of automobile bodies. Descriptions of the striking new models appearing at the leading plages of the Continent, forwarded by a Hayes Body Corporation representative, are of invaluable assistance to them.

Similar connections in all the cultural centers of Europe keep Alexis Sakhnoffsky, recently appointed art director of the Hayes Body Corporation, informed daily of the trend of fashion. Mr. Sakhnoffsky won the Elegants contest at Monte Carlo for four successive years, and last year won the Gold Cup at the first Elegants contest in England.

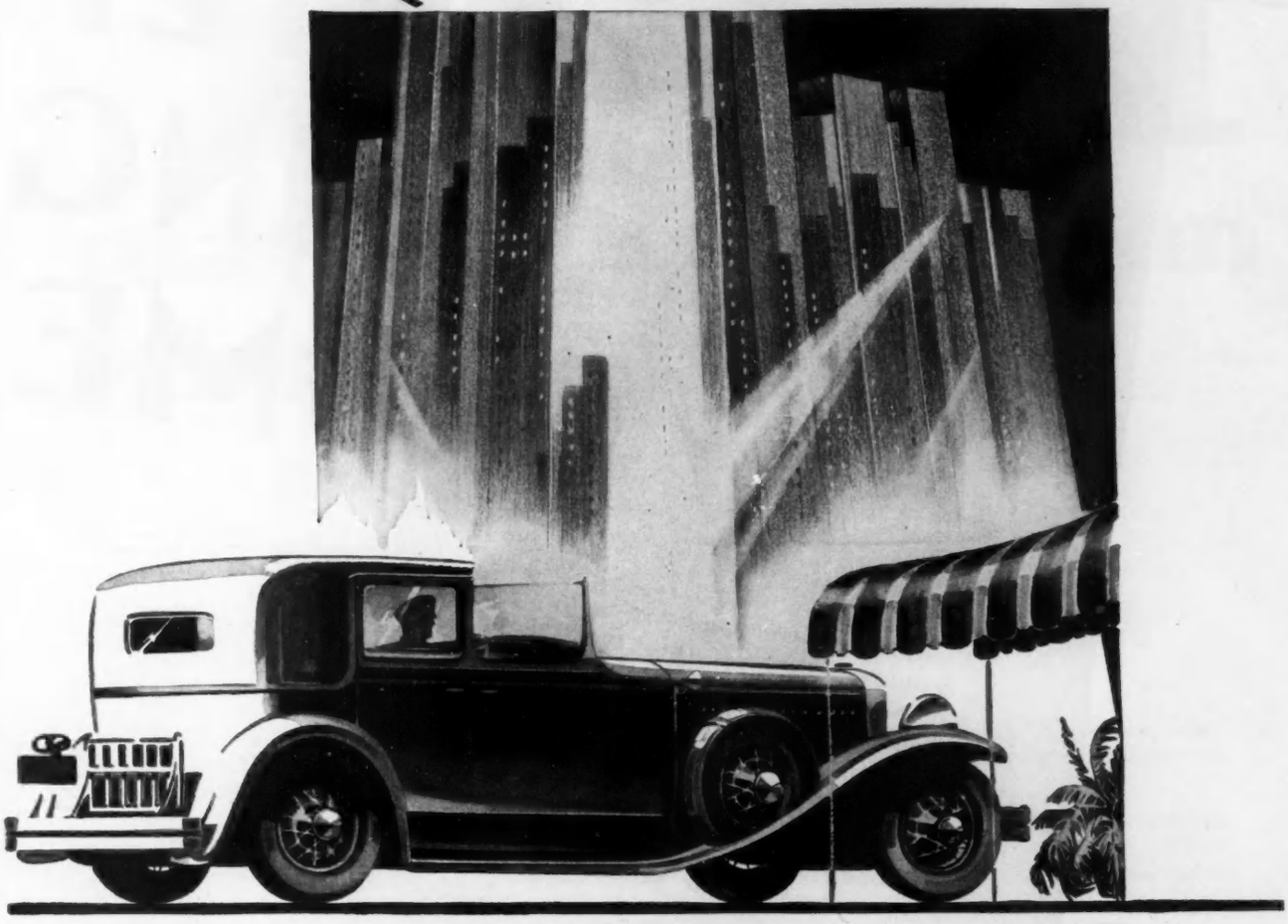
Thus Hayes is able to produce a new style months in advance of its acceptance by the automobile buying public.

HAYES *Body Corporation*

GRAND RAPIDS MICHIGAN



QUALITY



AUTO-LITE'S ***reputation for quality is the result of using only finest materials and workmanship . . . .***

OFFICIAL AUTO-LITE SERVICE

The Sign of Auto-Lite Service — a national protection for car and truck owners.

FOR 18 years one dominant thought has motivated Auto-Lite production—to build the finest quality into every Auto-Lite unit.

Experienced Auto-Lite engineers and master craftsmen have worked together—their efforts have produced high quality, which has long been recognized throughout the entire world.

This policy has been an important factor in making Auto-Lite the world's largest independent manufacturer of starting, lighting and ignition systems.

THE ELECTRIC AUTO-LITE COMPANY
Office and Works: Toledo, O.
Also makers of Dé Jon

Auto-Lite

Starting, Lighting & Ignition

CONSTANTLY INCREASING VOLUME

A constantly increasing list of motor car manufacturers are learning the wisdom of using the Interchangeable type of Bohn Ring True Bearings. Thus each month the demand for this design is continually growing greater.

No hand fitting—no reaming. This advanced design effects a decided economy by decreasing your production costs.

Machined to precision limits. Maximum variation in essential dimensions does not exceed .00025.

BOHN ALUMINUM & BRASS CORP., DETROIT, MICHIGAN
New York Chicago Philadelphia Cleveland Pittsburgh

YOU

may be just the man who can use

BOHNALITE

62% LIGHTER THAN IRON

Many men believe they must continue to use iron in the products or merchandise they make merely because they have always done so.

As a rule, these same executives are not familiar with the economical advantages of Bohnalite.

Are you?

You may be just the man who can use Bohnalite to advantage.

For here is a metal 62% lighter than iron—possessing all the advantages of iron but none of its disadvantages.

Bohnalite has high uniform hardness—great density—fine grained structure—exceptional strength—excellent bearing qualities—and is ductile.

Many of these important refinements are due to the special processes and series of heat treatments developed by Bohn metallurgists over a long period of years.

Why not send us your blue prints and samples. Let us figure with your engineers and show you the many advantages of Bohnalite, a new light alloy.

Send us your blue prints and ask for the latest Bohnalite booklet.

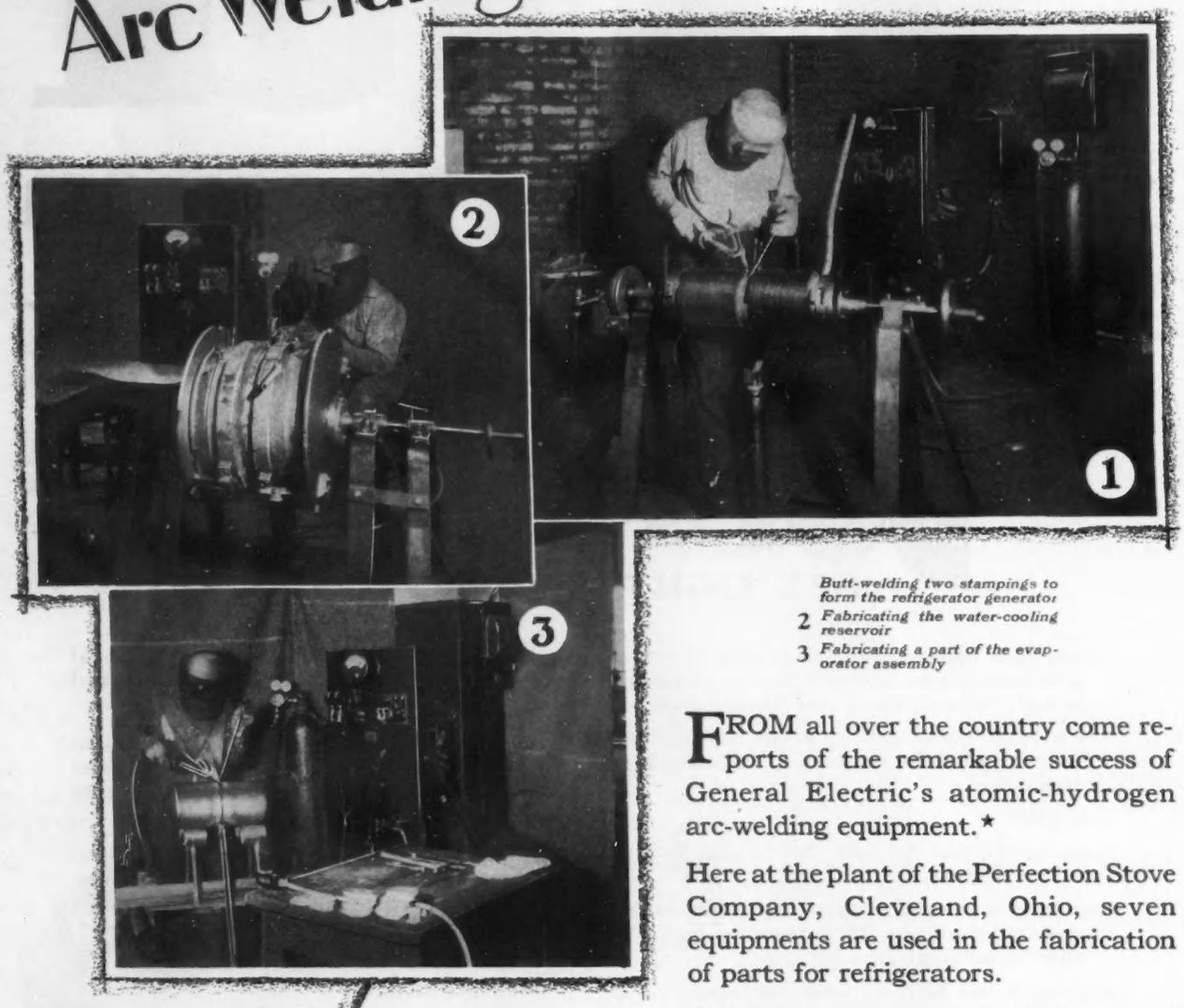
BOHN ALUMINUM & BRASS CORPORATION, DETROIT, MICHIGAN

New York Chicago Philadelphia Cleveland Pittsburgh

CHAS. B. BOHN
The authority who developed Bohnalite

Atomic Hydrogen Arc Welding

At the Perfection Stove Co.



Butt-welding two stampings to form the refrigerator generator
2 *Fabricating the water-cooling reservoir*
3 *Fabricating a part of the evaporator assembly*

FROM all over the country come reports of the remarkable success of General Electric's atomic-hydrogen arc-welding equipment.★

Here at the plant of the Perfection Stove Company, Cleveland, Ohio, seven equipments are used in the fabrication of parts for refrigerators.

This company reports that this type of welding is from two to five times faster than the gas welding formerly used—and even more important, the quality of the welds is not approached by any other type of welding.

Complete details as to this job or the application of atomic-hydrogen arc welding to your product are available through your nearest G-E office.

★The atomic-hydrogen arc-welder—originated by General Electric—will weld very thin metals, and metals and alloys hitherto considered unweldable. In addition, it has been found to produce exceptional results in general welding.

THE MORE YOU ARC WELD THE MORE YOU SAVE

530-62

JOIN US IN THE GENERAL ELECTRIC HOUR, BROADCAST EVERY SATURDAY AT 8 P.M., E.S.T. ON A NATION-WIDE N.B.C. NETWORK

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES

MADE OF THE FINEST high carbon chrome alloy steels, Federal Radial Ball Bearings possess unusual *stamina*. Long life and dependable wear are characteristics of these bearings—characteristics which mean economy and absence of trouble. Consequently, the performance of "Federals" is just as pronounced as their quality. That is why manufacturers select Federal Radial Ball Bearings in preference to ordinary bearings.

We shall be pleased to forward samples, quotations and complete information to those interested.

THE FEDERAL BEARINGS CO., INC., POUGHKEEPSIE, NEW YORK

FEDERAL

RADIAL BALL BEARINGS

Restful Riding

'til the last mile rolls up

New car comfort is no longer a new car feature, that fades as the miles roll by. The inevitable wear of old style shackles; the nerve racking squeaks and rattles; the need of frequent adjustment and greasing; the hard, uncomfortable riding from over-tightened shackle bolts—these are things of the past.

Ball Bearing Spring Suspension substitutes frictionless revolving balls for rubbing, oscillating bolts. It puts grease where the load comes, and keeps it there. Full, free flexing of the springs at all times is assured and shock absorber action is unhampered, always.

When Ball Bearing Suspension links the running gear to the frame the ease and comfort of riding heretofore considered a new car joy, remains 'til the last mile rolls up.

THE FAFNIR BEARING CO., Shackle Division, NEW BRITAIN, CONN.
European Agent: BENJAMIN WHITTAKER, Ltd., Aldwych House, London, W. C. 2, England

FAFNIR

BALL BEARING SPRING SHACKLES

OVER 100,000 MOTORISTS ARE RIDING ON FAFNIR BALL BEARING SPRING SHACKLES

Lovejoy

Duodraulic

FOR THE WORLD'S FINEST CARS

The new Lovejoy *Duodraulic* makes the world's finest cars as luxurious in riding quality as they are in appearance and appointment. ◈ ◈ It is more than a double-acting shock absorber. It is two hydraulic shock absorbers in one, each independent of the other. ◈ ◈ It not only checks rebound, but eases spring compression as well. Every road irregularity is compensated—every shock absorbed. Exceptional stability is the result. ◈ ◈ And in addition to unrivaled riding comfort, the new Lovejoy Duodraulic offers many other important advantages. Each large automatic relief valve maintains constant oil pressure and makes adjustments due to temperature unnecessary. The flexibility of action may be regulated to suit your preference ◈ ◈ If you want the finest shock absorbing equipment, investigate the Lovejoy Duodraulic through any Authorized Lovejoy Distributor or Branch of United Motors. Lovejoy Duodraulic Shock Absorbers are sold in sets of four at $125, including installation.

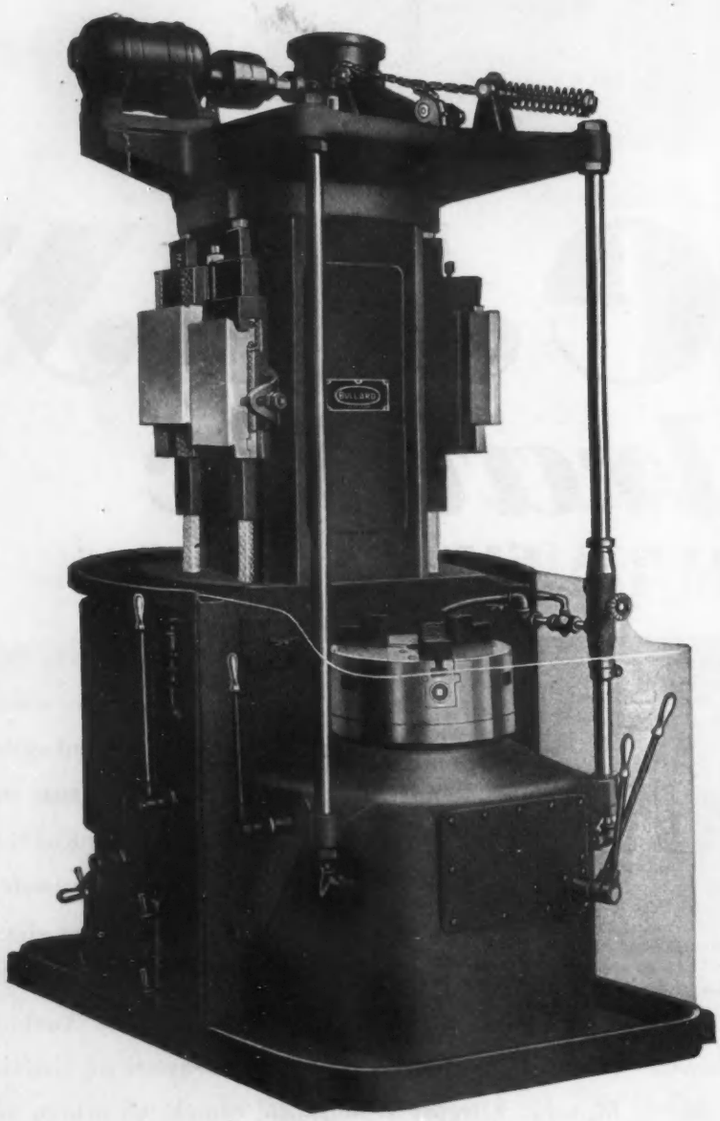
The original Lovejoy Hydraulic Shock Absorbers are giving satisfaction on more than a million cars—and have been adopted as standard equipment on more makes of cars and buses than all other hydraulic shock absorbers combined.

DELCO PRODUCTS CORPORATION, DAYTON, OHIO

SET OF FOUR $125.00

AUTO-MATIC Vertical Turret Lathe

Production with a METHOD—large or small quantities—increased Profits



A definite method built into the equipment which makes up your production line gives a unity to the process that means smooth flow of work and lower costs. Progressive manufacturers have learned that the Bullard method is truly Production and Bullard equipment are the "key" units in any production line.

THE BULLARD COMPANY

Bridgeport, Connecticut

IN A HIGH-BEAMED HALL, hung with gorgeous purple curtains and brilliant tapestries, the Anglo-Saxon baron plays host with a lavish hand. ◆ ◆ ◆ His guests... colorfully and richly appareled . . . surround the long banquet board. ◆ ◆ ◆ They rest upon strikingly carved and brightly covered benches . . . They drink rare wines from goblets of purest gold and silver. ◆ ◆ ◆ Barbaric, dazzling hues — reds . . . purples . . . blues . . . yellows . . . golds . . . greens — truly reflected the bold, vigorous life of the ancient Anglo-Saxons. ◆ ◆ ◆ Today, subtly refined and blended in exquisite harmonies by Arco color-engineers, these colors attain their rarest beauty in Arcozon, the perfect finish for fine motor cars. ◆ ◆ ◆ May our representative call soon . . . bringing the complete story of the Arco pyroxylin lacquer system?

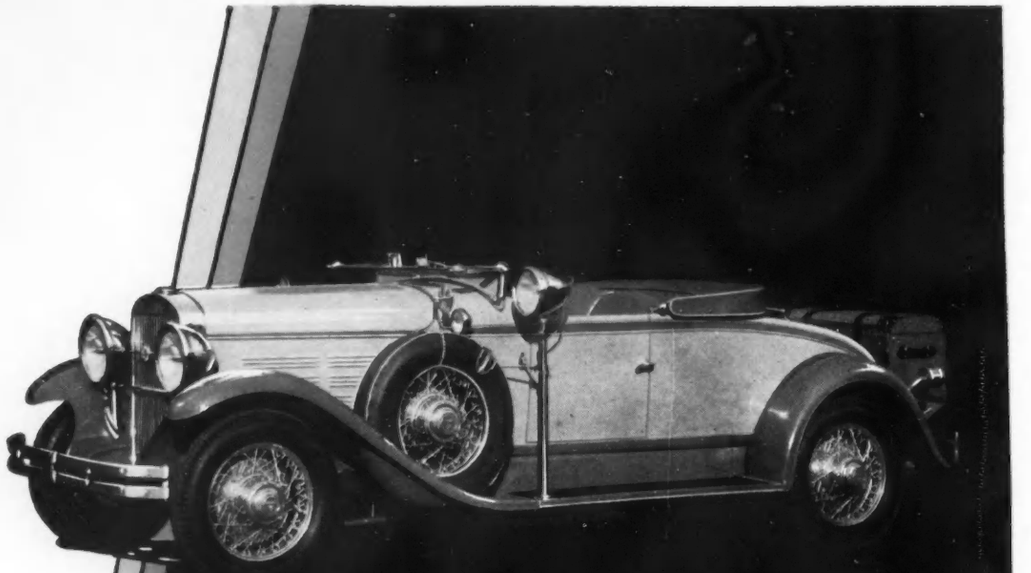
THE ARCO COMPANY ✓ *New York, Chicago, Detroit, San Francisco, Dallas* ✓ CLEVELAND, OHIO
PAINTS ✓ VARNISHES *In Canada: The Arco Co., Ltd., Toronto, Ont.* ✓ ENAMELS ✓ LACQUERS

(210)

SPRAYS ON ARCOZON STAYS ON

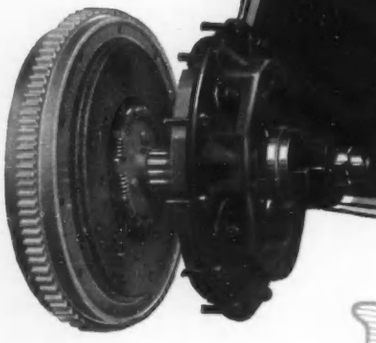
THE ARCO PYROXYLIN LACQUER SYSTEM

JORDAN



Long Clutches are used on all Jordan Automobiles

LONG PRODUCTS
Automotive Clutches and Radiators



LONG

LONG MANUFACTURING CO.
DETROIT MICHIGAN

MOULDINGS BY DAHLSTROM

. . . are important sales aids in the automotive market today . . .

To the discriminating buyer of the modern automobile, as well as to the experienced salesman . . . mouldings by Dahlstrom signify a perfection in detail that reflects the stability and perfection of the automobile you manufacture.

For Dahlstrom has developed a special cold drawn process that produces stronger and lighter mouldings whose precision fit and finer finish are acknowledged unparalleled in quality.

The services of the Dahlstrom engineering staff, and vast factory facilities, are ready to design and produce the mouldings you need. Write us today for further details.

DAHLSTROM METALLIC DOOR CO.

418 BUFFALO STREET

JAMESTOWN, NEW YORK

Established 1904

Detroit Chicago New York
Cleveland Philadelphia Los Angeles

WOMAN CUSTOMER: . . . *how interesting! I'd no idea manufacturers gave so much thought to perfecting a detail like a wheel.*

HEAD OF SALES AGENCY: *Wheels aren't a detail to Budd, madam—they're a life-study. And as to thought —those Budd people never stop* thinking.

BUDD DEVELOPED THE BEST DISC WHEEL IN THE WORLD

and they haven't stopped thinking yet!

BUDD DEVELOPED THE BEST WIRE WHEEL IN THE WORLD

The Budd-Michelin Disc Wheel—the safest automobile wheel in the world

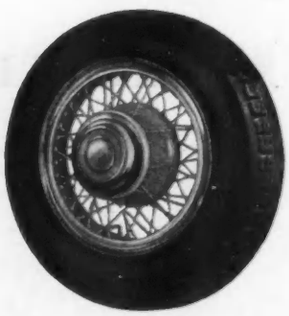
E V I D E N C E

Budd discovered that the secret of building better wire wheels was to preserve the original tension of each spoke. This was impossible with bent spokes, as the hooks invariably give slightly, lowering the original tension. Budd prevented this by designing the straight spoke wire wheel. This Budd feature not only maintains the original tension, but is stronger than any other wire wheel made. A typical example of Budd leadership

BUDD

WHEEL COMPANY

Philadelphia *Detroit*



The Budd Wire Wheel—the smartest wire wheel on the roads today

Squeaking brakes *are a* poor advertisement

MANY a car sale is made or lost without the prospective buyer ever entering the agency. For the public judges quality and value in motor cars quite as much by those seen on the highways as those seen on the display floor.

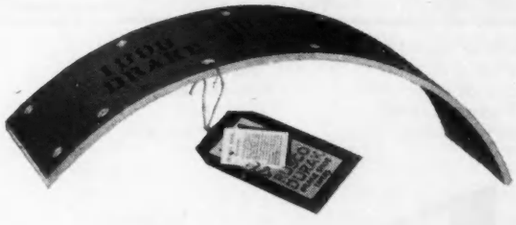
And certainly one of the things that can do much to create an unfavorable impression of an otherwise fine car is squeaking brakes.

Rusco Durak Brakeshoe Liners offer car manufacturers a means of providing smooth, noiseless brake action and quick-stop efficiency in wet weather or in dry.

Durak is a revolutionary new type of brake lining. It contains 50% more asbestos than ordinary lining, is built with the exactness of a bearing and outlasts other linings by from two to five times.

Because of its sturdy, rigid construction, accurate and lasting adjustment can be made at time of installation, thus insuring dependable brake performance without frequent adjustments.

We shall be glad to send to responsible executives in the motor car industry, without charge or obligation, a set of Durak Liners for a personal test. Simply fill out coupon and mail.



RUSCO DURAK
***Brakeshoe* LINERS**

THE RUSSELL MANUFACTURING COMPANY
Dept. B-52, Middletown, Conn.
(In Canada: The Russell Mfg. Co., Ltd., St. Johns, P. Q.)

Please send me free of charge and without obligation set of Rusco Durak Brakeshoe Liners for my car.

Name .....
Street .....City and State .....
Name of Motor Co. .....
Position .....
Make of Car .....
Year .....Model .....

NAGEL EXPERIENCE RESULTS IN NAGEL PRECISION

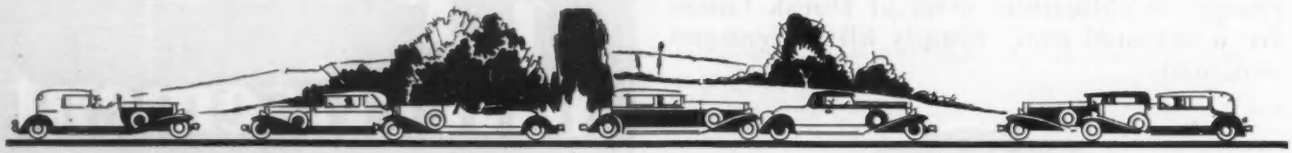
Nagel equipment—whether complete panels or separate instruments has gained its solid standing among automobile manufacturers on account of its uniform accuracy and precision. Thirty years of precision manufacture stand back of Nagel's reputation and thirty years' experience make this precision possible.

Nagel instruments are efficiently serviced by experienced Nagel service men at authorized Nagel service stations spread throughout the country.

Our engineers will be glad to cooperate with yours in the design of complete panels or individual instruments to meet your special needs.

NAGEL ELECTRIC COMPANY
TOLEDO .. OHIO

Pacific Coast Offices:
451 Rialto Bldg., San Francisco, Calif. 53 Fourth Street, Portland, Oregon
Canadian Representative: Auto Electric Service Co., Ltd., 252 Victoria Street, Toronto, Canada



Besides airplanes, motor trucks and motor boats, Nagel supplies instruments or panels for the following well-known motor cars:

Auburn	Durant Star	Reo Flying Cloud —the Master	Studebaker
Cadillac	Jordan	Reo Flying Cloud —the Mate	Stearns-Knight
duPont	LaSalle		Whippet
Durant	Pierce Arrow		Willys-Knight

NAGEL

Heat Indicators • Gas Gauges
Oil Pressure Gauges • Oil Level Gauges
Ammeters • Cigar Lighters and Complete Panels

This sign identifies Nagel authorized service stations

and is a sign of efficient, intelligent craftsmanship

The Pickwick "Nite Coach", designed by Dwight E. Austin, Chief Engineer, The Pickwick Corporation, Los Angeles, is equipped with many important parts of Chrome-Vanadium Steel.

In the Pickwick "Nite Coach" . . .

Vital Parts of Vanadium Steel

DESIGNED by Dwight E. Austin, Chief Engineer of The Pickwick Corporation, Los Angeles, and constructed entirely in the factory of the Pickwick Stages System, the "Nite Coach" is a distinct innovation in the field of night motor coach transportation. In addition to its sleeping accommodations for twenty-six passengers, the "Nite Coach" has complete dining service, with running water in each compartment.

In the construction of the "Nite Coach", only the finest materials, proven through service, were employed. Logically, Chrome-Vanadium Steel was selected for the axles, pinion shafts and brake pins in the rear axle construction. It was also employed in the motor for such important parts as valve springs, bearing studs, block studs and connecting rod bolts and nuts.

Because of its high strength, great toughness, resistance to shock and anti-fatigue properties, Chrome-Vanadium Steel is ideal for every automotive application where dependability is the prime consideration.

If you are interested in better steels for applications where high strength, toughness and durability are required, our Metallurgists will be glad to send you complete data on Chrome-Vanadium Steel. Write us.

VANADIUM CORPORATION OF AMERICA

120 BROADWAY, NEW YORK, N. Y.

CHICAGO *Straus Building* PITTSBURGH *Oliver Building* DETROIT *Book Tower*

Plants at Bridgeville, Pa., and Niagara Falls, N. Y.
Research and Development Laboratories at Bridgeville, Pa.

VANADIUM STEELS

for strength, toughness and durability

Mueller 600 BEARING METAL

Improves Your Product— Cuts Your Costs

In a wide range of industrial plants, Mueller 600 has solved production problems, reduced manufacturing costs and increased the efficiency of products on which it is used. Its tensile strength is from two to three times that of the best cast bronzes; it maintains a lower bearing temperature at all loads and speeds, thereby decreasing the coefficient of friction. A wide variety of tests demonstrate its superiority to phosphor bronze, cast gun metal, nickel bronze and other bearing alloys.

Some of the many purposes for which Mueller 600 has demonstrated its economy and efficiency are:

Connecting Rods, Worms and Worm Wheels, Gears and Gear Blanks, Spindles on Textile Machinery, Slip Rings for three-phase Motors, Seal Rings for Electric Refrigerators and Journal Boxes.

Mueller 600 is manufactured in the form of forgings, rod and screw machine parts. Let us show you how this remarkable alloy can promote efficiency and reduce manufacturing costs in your plant.

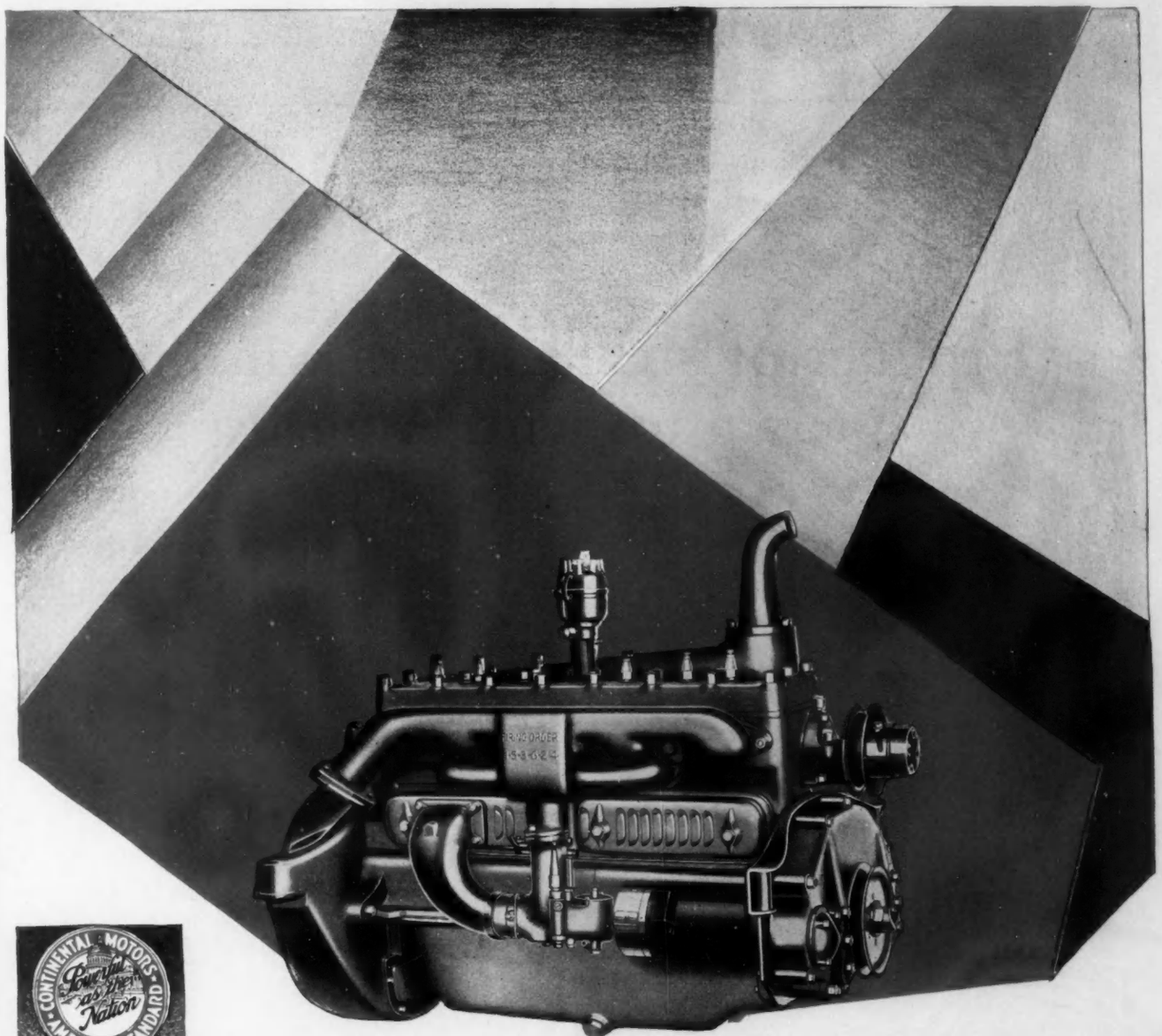
Mueller Brass Co.
PORT HURON - - MICHIGAN
DETROIT DISTRICT

Offices:

New York, Philadelphia, Pittsburgh, Buffalo, Detroit, Cleveland, Chicago, Milwaukee, Dayton, Flint, New Orleans, Minneapolis, St. Louis, Indianapolis

Mueller Brass

THREE GENERATIONS OF BRASS MAKING



CONCENTRATION ON ENGINE DEVELOPMENT

—The advantages which Continental offers to both large and small manufacturers of automotive equipment are many. ¶ The Continental organization, specializing and concentrating on gasoline engine development, is keyed to produce specific types of engines in any quantities on short notice. Large manufacturers thereby cut their investment in new equipment and are assured quick deliveries. Small manufacturers secure high quality engines at a cost possible only through Continental's unequalled facilities for quantity production.

CONTINENTAL MOTORS CORPORATION
Offices: **Detroit, Mich., U. S. A.** ***Factories:*** **Detroit and Muskegon**
The Largest Exclusive Motor Manufacturer in the World

Continental Motors

THE SATURDAY EVENING POST

WHEELING

COP-R-LOY

Reg. U. S. Pat. Office

THE COPPER ALLOYED STEEL

Product of steel makers who have grown up with America

WITH one of the first primitive blast furnaces built in America in 1715, there began the experience which, nearly two hundred years later, has resulted in a most important advance in the development of steel—COP-R-LOY, the Copper Alloyed Steel.

Twenty years ago the need was [illegible] for a practical, workable [illegible] tensile strength [illegible] product [illegible]

The metallurgists [illegible] Steel Corporation, with [illegible] background of experience, carried through to successful conclusion, their experiments combining copper with refined steel, producing a new steel alloy which was destined, within a single generation, to establish a new standard of efficiency in its particular field.

Having grown up with America, it is only to be expected that the Wheeling Steel Corporation today should own and control every factor in the [illegible] ties [illegible] a product [illegible] manding strict [illegible] tonnage to meet modern [illegible]

COP-R-LOY is steel made [illegible] than ever, and through its use manufacturers may confidently expect to lower their costs, speed up operations, and deliver a more satisfactory and lasting product.

COP-R-LOY
WHAT IS IT

COP-R-LOY, the Copper Alloyed Steel is a refined steel to which, while molten, pure copper has been added. It is distinguished from other ferrous metals by the fact that in its making the essentials of strength, malleability and indifference to fatigue are *combined* with greater durability—a quality of importance wherever [illegible] metals to deter[illegible] lem[illegible]

Every day—Millions of Gallons of Gasoline are loaded into automobile tanks made of COP-R-LOY, the Copper Alloyed Steel.

WHE[illegible]
W[illegible]

Wheeling Corrugating Compa[illegible]
La Belle Coke Company · Acke[illegible]
La Belle Transportation Company · F[illegible]
The Consolidated Expanded Metal [illegible]
Consumers Mining Company

"FROM MINE TO MARKET"

WHEELING STEEL

Reg. U.S. Pat. Off.

MORE new cars were built in the first quarter of 1929 than in any previous quarter...

MORE of them were equipped with Carter Carbureters than with any other make...

CARBURETER

CARTER CARBURETOR CORPORATION, SAINT LOUIS

a.c.f.

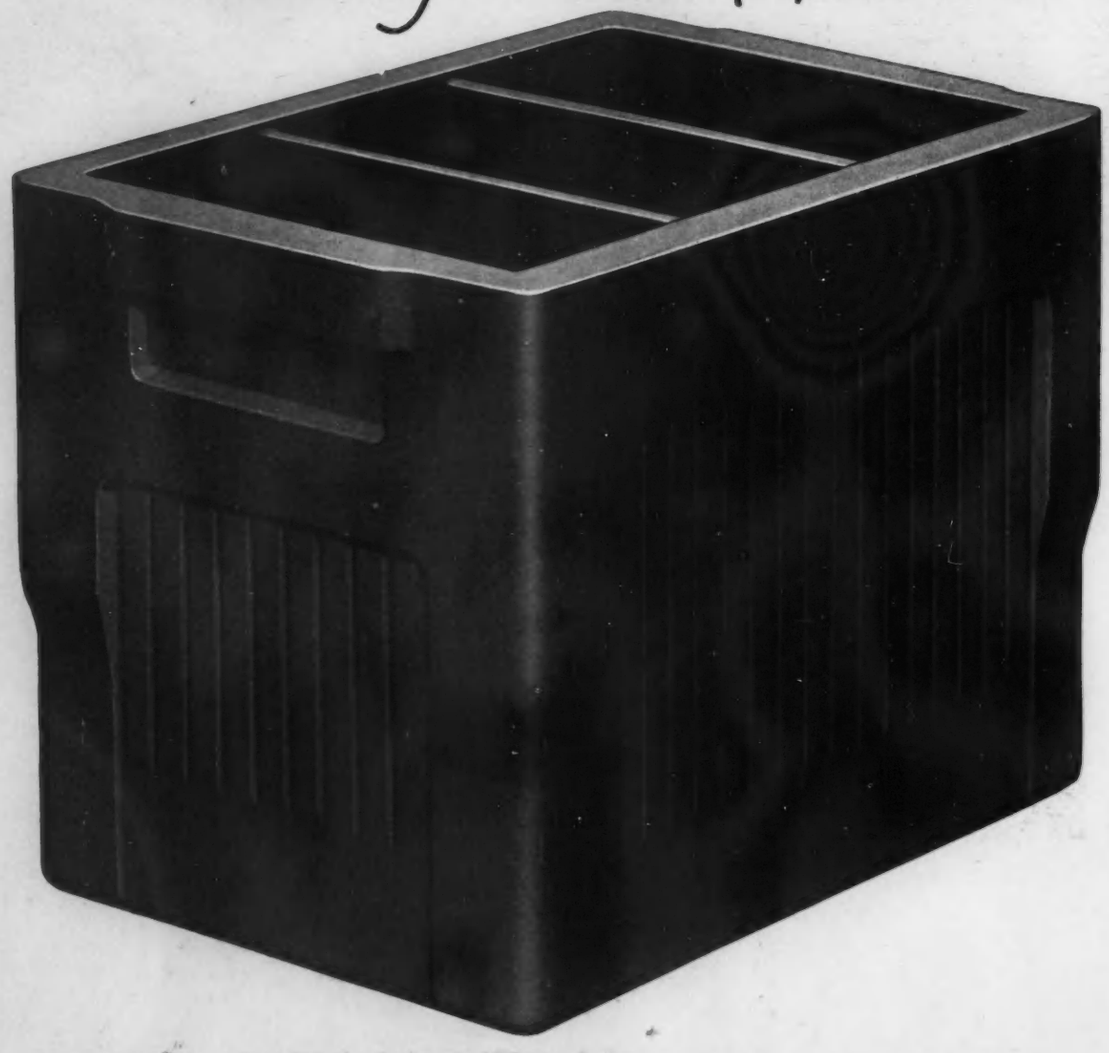
"And Now" The

~~14TH MILLION~~

15TH MILLION

RICHARDSON CASE

"Standard for Initial Equipment"



The RICHARDSON COMPANY

Automotive Division

LOCKLAND (CINCINNATI) OHIO

Good - Better - Best!

MERELY a MATTER of PENNIES

SKF Bearings are admittedly the highest priced bearings in the world, and yet the difference between these and ordinary bearings can often be expressed in pennies.

A difference in pennies standing between ordinary steels and SKF's specially processed steels from ores taken from its own mines. A difference of pennies between ordinary inspections and the repeated rigorous, searching, flaw-seeking inspections that are the price of perfection and part of the every-day production routine in every SKF plant in the world.

A difference in pennies that would be wiped out perhaps with the cost of the first adjustment that some types of bearings require.

There are certain SKF Bearings, of course, that it is not possible to consider on a price comparison basis for reason that nothing like them is made by any other bearing company in the world. But where automotive bearings are concerned the difference in cost is merely a matter of pennies.

2287

SKF Ball and Roller Bearings

SKF INDUSTRIES, Inc.

40 East 34th Street, New York, N. Y.

"THE HIGHEST PRICED BEARING IN THE WORLD"

KINGSTON
VACUUM FUEL FEEDING SYSTEM

FOR nearly thirty years the name of Kingston has been linked with progress and improvement in the automotive equipment field. Now the Kingston Vacuum Tank and Booster, a new and superior fuel feeding system, has been acclaimed an engineering triumph—demonstrated by its ready acceptance by an imposing list of automobile and truck manufacturers.

The Kingston Vacuum Tank and Booster increases intake manifold suction 300 to 500 percent at wide open throttle, where the ordinary fuel system operates at its lowest efficiency.

Used as
Standard Equipment
on the following
Cars *and* Trucks

CARS	TRUCKS
CHANDLER	FARGO
CHRYSLER	FEDERAL
DeSOTO	DODGE
DODGE	GRAHAM
ELCAR	INDIANA
KISSEL	INTERNATIONAL
MARMON	RELAY
NASH STANDARD	REO
PLYMOUTH	SELDEN
STUTZ	

KINGSTON PRODUCTS CORPORATION

Manufacturers of Carburetors, Fuel Feeding Systems,
Vacuum Tanks, Oil Pumps and Car Heaters

KOKOMO, INDIANA

ROSS *Cam & Lever* STEERING

The Ross engineering staff is unusually equipped to render intelligent assistance in front-end design, and in the adaptation of steering gears to meet difficult installation conditions. Their broad experience in designing and supplying steering gears for the majority of cars, trucks and buses is available to any manufacturer.

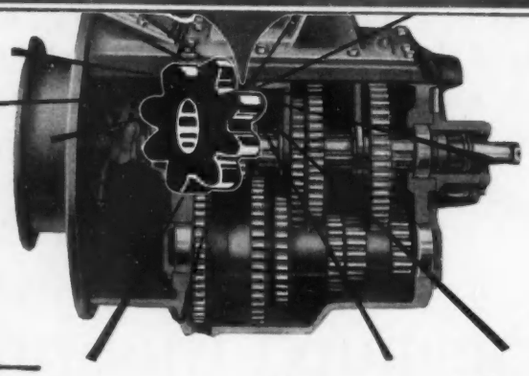
ROSS GEAR & TOOL COMPANY

Lafayette, Indiana

A three ton PRESSURE

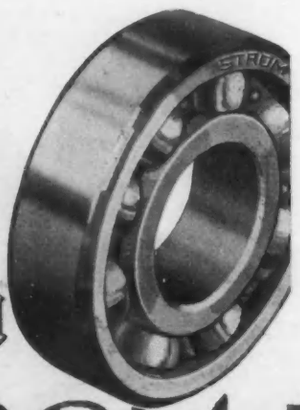
ON

A ONE INCH GEAR TOOTH



Yet

Super-Strom Ball Bearings Maintain Shaft Rigidity in Transmissions



Strom BALL BEARINGS

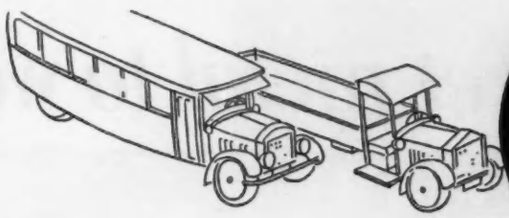
Transmission gears may develop tooth pressures as high as 5,000 to 6,000 pounds per inch of face in low speed or reverse. Under these tremendous loads the least shaft displacement will change gear tooth alignment and produce gear failure.

For Shaft rigidity the Super-Strom Ball Bearing is ideal. Its deep, uninterrupted race grooves resist pressures from all angles. The Super-Strom is wear-proof and never loses its original fit up. It holds shafts rigidly in their original position and keeps them there. This wear-proof, permanently adjusted Ball Bearing is best for transmission gear support. Specify the Super-Strom.

STROM BEARINGS CO.

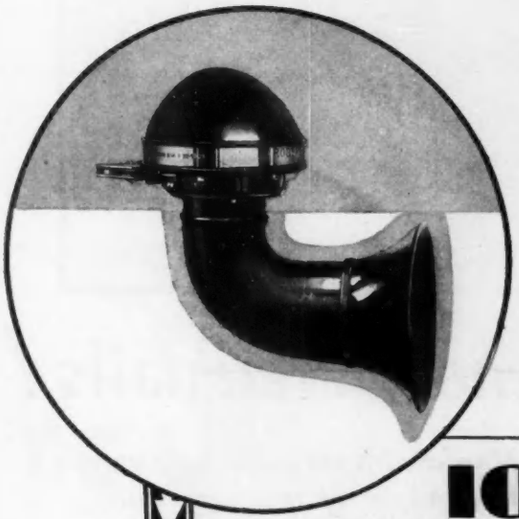
DIVISION OF MARLIN-ROCKWELL CORPORATION

4554 PALMER ST., CHICAGO, ILL.



Only a Robert Bosch Vibro-Balanced Horn

gives ALL of the 10 horn essentials



"IT'S the only horn which has never given us any trouble of any kind. We have never found it necessary to replace one after 4 years of service, or even make an adjustment." ... "For dependability they are in a class by themselves—little care and lots of service." ... "It is an excellent horn. The maintenance on the 8 we have has been very reasonable."

To the manufacturer of commercial cars, such testimony from fleet owners is important. For it points the way that you can offer to the users of your own trucks and busses a long life horn ... a horn that will last for years without need of service ... a horn that can be depended upon in rain or snow or fog or dirt or dust.

There are important constructional reasons why the Robert Bosch horn gives such unparalleled, uninterrupted, long-lasting service. It is the only horn that embodies the principle of Vibro-Balance ... the only horn that combines the 10 essentials of horn satisfaction listed at the left.

Robert Bosch now offers a complete line of Vibro-Balanced Horns to choose from ... for outside mounting ... for under the hood ... at a wide price range depending upon the service required. Ask your engineering department to check the horn with which you are now equipping your busses or trucks, against the ten standards of horn performance. If it fails in one or more essentials, investigate the line of Vibro-Balanced Horns. We will be pleased to send you full information.

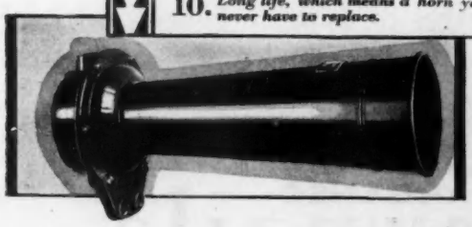
10 Horn Essentials

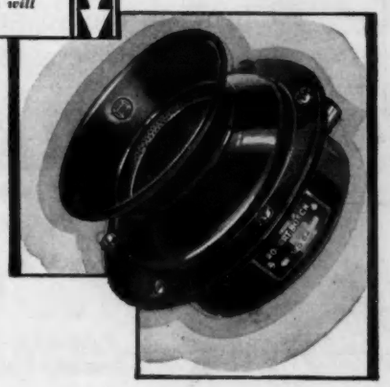
1. *Authoritative tone that compels unquestioned right-of-way and immediate attention from pedestrians.*
2. *Instantaneous, hair-trigger response to the button. The split-second difference often prevents accidents.*
3. *Far reaching pitch which soars above traffic din; penetrates further on countryroads.*
4. *Unfailing dependability which gives the driver restful confidence because he knows that his horn will not break down.*
5. *An even tone that will always maintain its well-rounded richness—a permanent tone that will not sound hoarse or husky, even after years of service.*
6. *A distinctive musical tone pleasing to all and offensive to none.*
7. *Effective warning even when the battery is not fully charged.*
8. *Weatherproof construction which defies rain, snow, dirt and dust, even when for greater effectiveness the horn is mounted outside instead of under the hood.*
9. *Freedom from need of service which makes lubrication or adjustment unnecessary.*
10. *Long life, which means a horn you will never have to replace.*

Only Robert Bosch Vibro-Balanced Horns are Original-Bosch Horns. For your protection look for the full name Robert Bosch and this trade mark . .

The Original Bosch

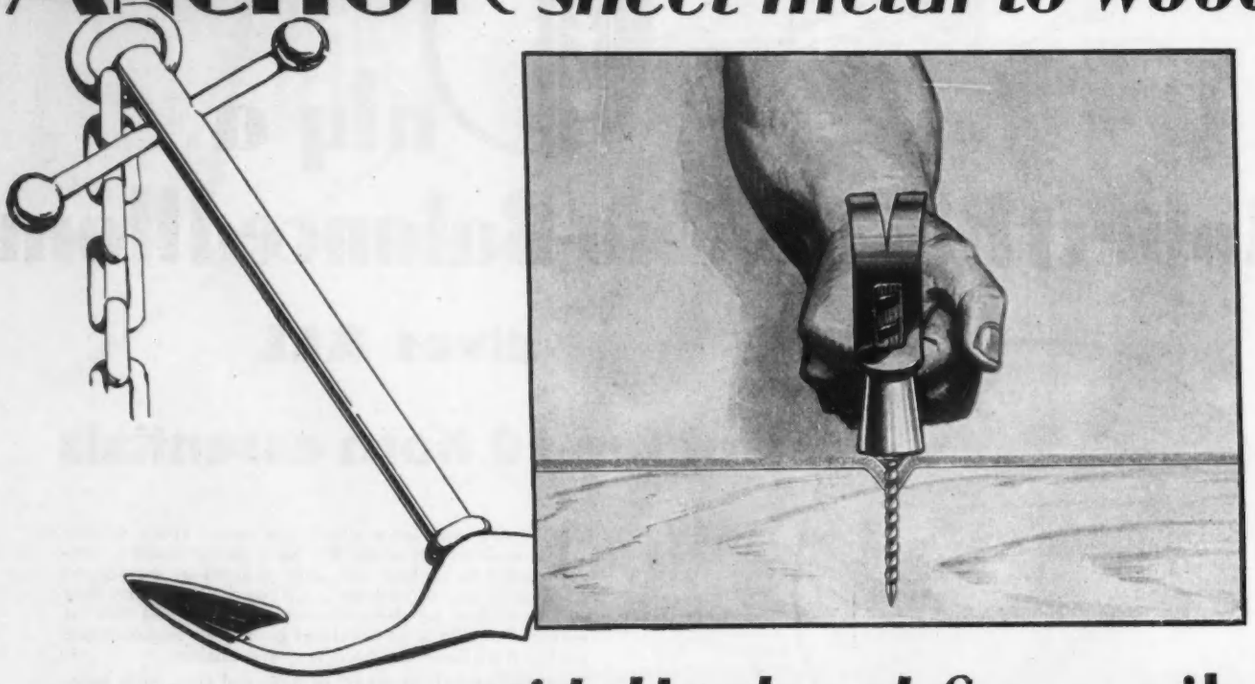
ROBERT BOSCH PRODUCTS



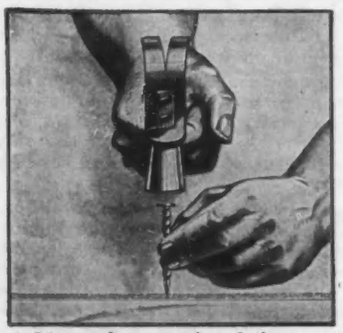


We shall be glad to furnish further information about Vibro-Balanced Horns. Robert Bosch Magneto Co., Inc., 3605 F Queens Blvd., Long Island City, N. Y.

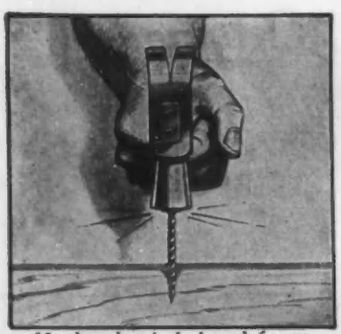
ANCHOR *sheet metal to wood*



..with Hardened Screwnails!



No need to punch a hole... sharp needle point pierces sheet metal with ease.



Hardened spiral thread forms a thread in the sheet metal and wood as you drive it in.

Tests prove that Hardened Screwnails have over 4 times the holding power of ordinary nails.

As the Hardened Screwnail is hammered in, its needle-pointed pilot forms a burr in the sheet metal. And the hardened spiral thread cuts into the burr and into the wood, securely anchoring the sheet metal to the wood.

Screwnails will not loosen, back out or pull out. And they are so hardened that they do not bend or break off.

Screwnails can be used to advantage by sheet metal workers, roofers, fireproof window and door manufacturers, automobile manufacturers and body builders, railroads, sign makers, refrigerator manufacturers and others who fasten sheet metal to wood.

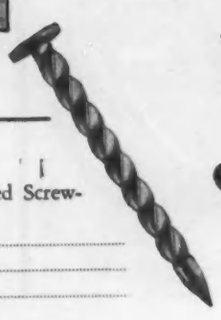
Check up the advantages of using Screwnails on your work. The coupon brings samples for trial—free.

PARKER-KALON CORPORATION,
198-200 Varick Street, New York

Please send me a handful of Hardened Screwnails. I want to try them out for

Name.....

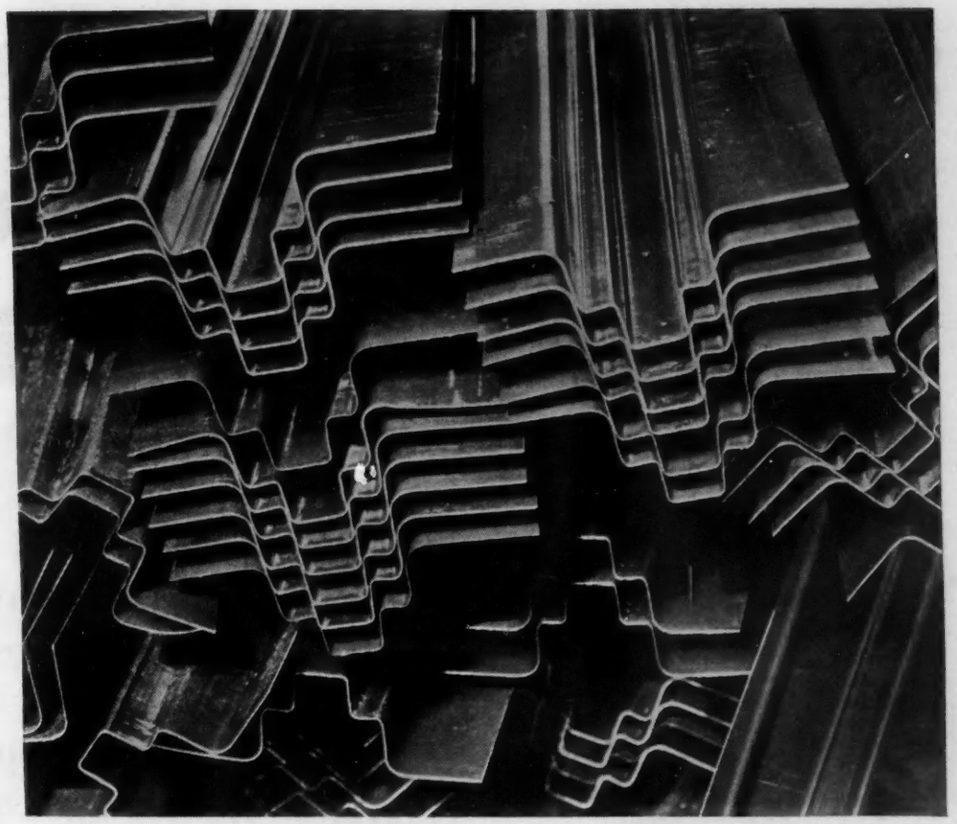
Address.....



PARKER-KALON
HARDENED
*Screw*nails

PATENTED JAN. 22, 1924-No. 1482151
OTHER PATENTS PENDING

PARKER-KALON CORPORATION
198-200 VARICK STREET NEW YORK



DG-36-A

delivered Sunday night as promised

Of course, "lack of time" when it is the customer's fault is a perfect alibi for sub-standard work. But a good alibi won't make a mediocre stamping do a first-class job. And no matter what the circumstances, a customer *must* get a top-notch stamping when he orders from Clayton & Lambert. For that is the only kind permitted to leave our plant. Yet—we have never failed to make delivery "when needed."

These self-imposed regulations were given a stiff test a few Saturdays ago. Early in the day a client asked us if we could furnish him a shipment of stampings of part number DG-36-A. He needed them on Monday morning. We told him the parts could be ready. So he sent us his dies and steel.

Then we discovered that his dies would not do a satisfactory job. They would make metal stampings—but not the quality our client needed. Nor the quality we demand of ourselves. Therefore in justice to our client and ourselves we *could not use* those dies as they were. They had to be reworked.

Time was short. Yet the job had to be done regardless of all handicaps and any hardships which they worked. It was necessary to retain a large force of men. And, in addition, virtually all the company's executives stayed at the plant all day Saturday, Saturday night, and Sunday. On Sunday night the stampings were delivered. And they were precisely what they should be!

This incident shows how quickly we can serve Detroit manufacturers. But whether your assembly line is "just around the corner" or hundreds of miles away—you can bank on Clayton & Lambert making your delivery "when needed."

CLAYTON & LAMBERT
Manufacturing Co., Detroit, Michigan

Steering Engineering IS JUST AS Important AS Body Designing

SINCE the advent of balloon tires, four-wheel brakes, front-wheel drives and other front-end weights, all automotive engineers have placed a new importance on steering ease. So, too, buyers of motor cars consider ease of steering and ease of control equally as important as performance, beauty, reliability and price.

It is significant that Gemmer engineers have been called upon to design steering gears for cars in all price classes and that more cars are equipped with Gemmer than with any other make of steering gear . . . ample proof of the statement that the most popular cars are those easiest to steer.

And, surprising as it may seem, many manufacturers have learned they can buy "steering by Gemmer" at a lower price than the cost of making their own steering gears . . . gaining as an additional premium the preference of motor car buyers for Gemmer-steered cars.

GEMMER MANUFACTURING COMPANY
DETROIT, MICHIGAN

GEMMER

Smoother Steered When Gemmer Geared

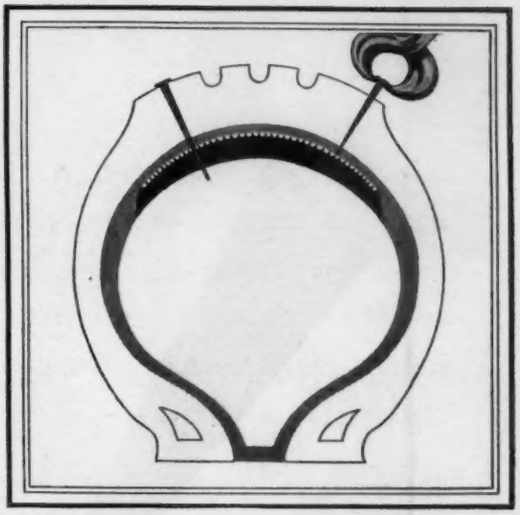
Not only NEW...
but REVOLUTIONARY

Goodrich announces the remarkable Air Container *to replace Inner Tubes*

Seals punctures . . . Strengthens tires . . . Adds mileage!

1 THAT'S BAD! Looks like certain trouble here, as any motorist knows from frequent experience. But this motorist is riding on Air Containers! See what happens . . .

2 OUT IT COMES! A pair of pliers pulls out the nail . . . and away goes the car as if nothing had happened! No flat . . . no loss of air . . . and *no slow leak!* How can it be?



3 HERE'S THE REASON WHY! See that black area? That is a segment of soft rubber, under constant compression. The instant the nail pierced that segment, the soft rubber gripped it tightly, allowing no air to escape. As the nail was withdrawn, the rubber pressed in behind the point, sealing the hole perfectly, automatically, instantly. Not an ounce of pressure lost!

IT'S here! A revolutionary new tire development that supplants the old-fashioned inner tube.

Sponsored, perfected and guaranteed by Goodrich . . . it is now available to those seeking safety and freedom from tire troubles.

Here's what the Air Container does:

It seals punctures on running wheels . . . users have picked up nails, tacks, screws, pieces of tire chain . . . and driven on them for miles without the loss of a pound of air!

It maintains air pressure. Users have gone for months . . . from July, 1927, to March, 1928, in one instance . . . without adding an ounce of air to their tires.

It strengthens the whole tire. One user traveled for two weeks after cutting the tire on a stone. On removing the casing, he found that the Air Container itself had been cut to the thickness of an ordinary inner tube . . . yet no deflation resulted in two weeks' normal use.

How it Works

The diagram above shows how the Air Container works. When a nail pierces the Air Container, the compressed soft rubber grips it tightly . . . seals it against loss of air. As the nail is removed, this compressed rubber instantly fills up the hole, before air can be lost.

In addition . . . the Air Container is considerably heavier than the ordinary inner tube. Its thicker walls take up the force of bruises and blows often preventing serious damage to the casing.

See your nearest Goodrich dealer about the new Air Container without delay. It offers you new security, new peace of mind, new mileage, new economy . . . in fact, revolutionary new performance from tires, whether on personal or business cars.

The B. F. Goodrich Rubber Co., Est. 1870, Akron, Ohio. Pacific Goodrich Rubber Co., Los Angeles, California. In Canada: Canadian Goodrich Co., Kitchener, Ontario.

Goodrich Air Containers

Modern Carburetion

ECONOMY with power, fast get-away, quick acceleration and speed can be supplied only by those carbureter manufacturers who have kept pace with the requirements and demands of present day transportation.

Marvel Carburetion Systems with the exclusive patented feature of automatically controlled heat applied directly at the throttle hold the spotlight of the industry.

Backed with enviable engineering, manufacturing and service resources, Marvel carburetion is an asset to any car.

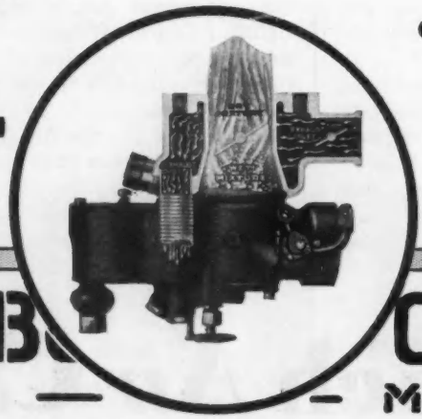
Marvel is Standard Equipment

on

BUICK, NASH,
OAKLAND, PONTIAC,
HUDSON, ESSEX

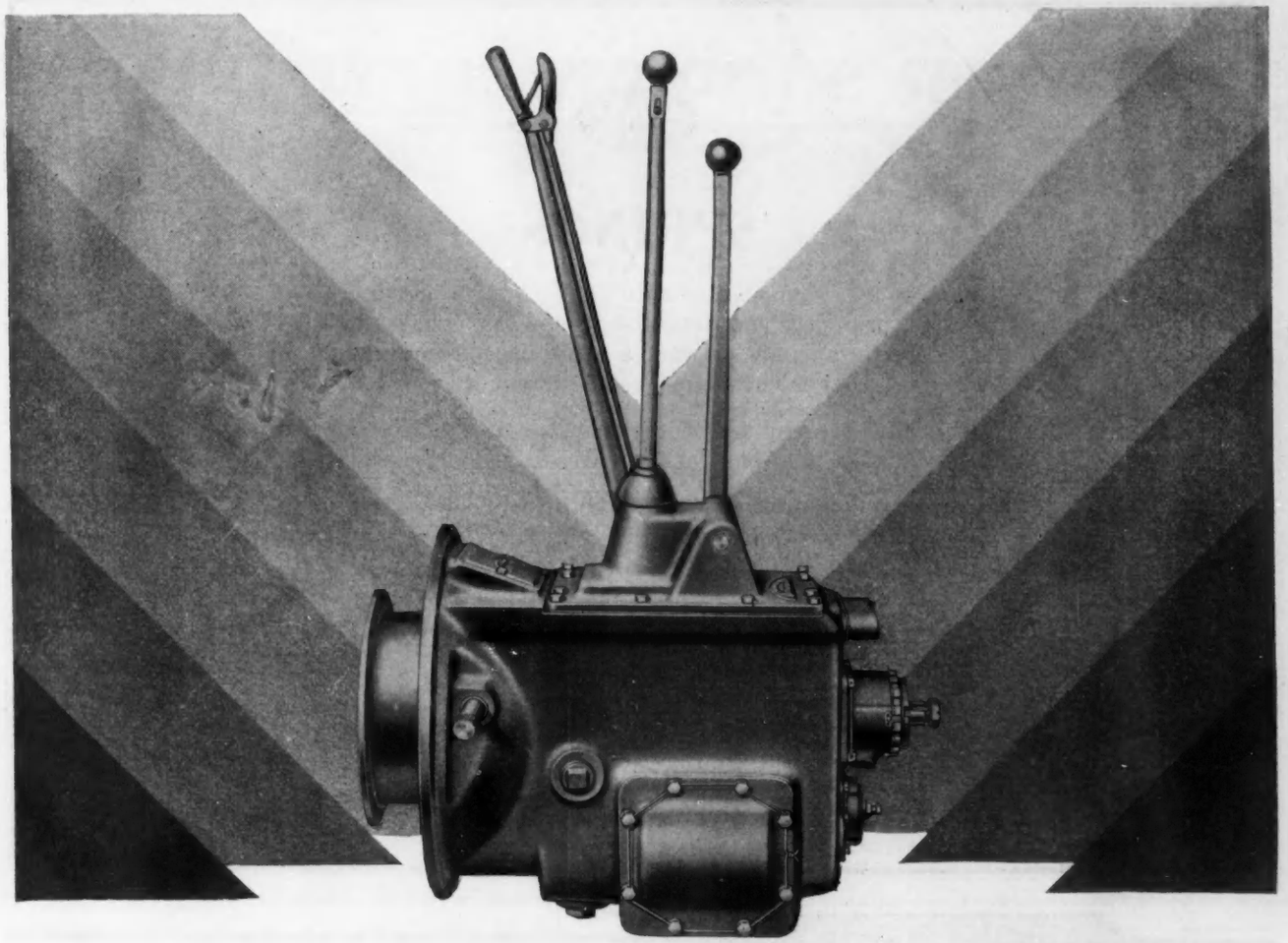
MARVEL

With Automatic Heat Control



MARVEL CARB[illegible] COMPANY

FLINT — — — — MICHIGAN



THE new Model 51, 5 speed transmission, pictured above, is the latest development of the Brown-Lipe Gear Company, pioneers in the manufacture of clutches and transmissions.

Model 51, like every other Brown-Lipe unit, was built step by step to meet a certain specific problem in the automotive industry.

Brown-Lipe experience and Brown-Lipe engineers are constantly at your service to help you solve any clutch or transmission problems. Call on them at any time and be assured of 100% co-operation!

BROWN-LIPE GEAR CO.

BROWN-LIPE GEAR COMPANY

Syracuse, N. Y.

Detroit
New York
San Francisco
London, England

BROWN-LIPE GEAR

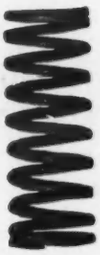
B.G.R.

SPRINGS

Chances are even at any rate that you are getting good springs, promptly and dependably, now. If you would like to get better springs, or want a little more prompt delivery, or a more convenient source, tell us about it.

We believe we can be of real service to the engineer on spring design, and our facilities are at your disposal.

We are equipped to make all types of round wire and small flat springs or any material.



BARNES-GIBSON-RAYMOND-INC.

MANUFACTURERS OF

SPRINGS OF ALL DESCRIPTIONS

6400 MILLER AVENUE

DETROIT, MICH.

DANLY DIE SETS

these Special Features

SAVE 20 to 50% in first cost . . . to start! Relieve drafting room and purchasing department of much detail.

You save 40 to 80% in die makers' time . . . for all Danly Die Sets are completely assembled, ready for immediate use, working surfaces accurately machined. Punch holder and die shoe held in perfect alignment "without perceptible shake," means dies cannot shear, long die life, maximum "pieces per grind" and minimum "depth per grind." Dies are as accurate as the die sets . . . regardless of press conditions. Ample clamping surface.

Inventory and capital are minimized, because all parts interchangeable, standardized. So convenient to order.

Telegraph or telephone immediate delivery from Stock

You can order by catalogue number . . . as easily as writing out a requisition upon your own stock room. So convenient!

DANLY MACHINE SPECIALTIES, INC.

2104-2130 SOUTH 52ND AVENUE, CHICAGO.

DETROIT, MICH. 1537 TEMPLE AVE.

DANLY STANDARD

LONG ISLAND CITY N.Y. 36-12 34TH STREET

Send for your copy of this valuable book free upon request. Send for it today.

Die Sets
Leader Pins and Bushings
Cap and Set Screws
Pressure-Pad, Stripper Plate
Knock-out Springs
Shanks, Bolster Plates, Laps

Could your motor be serviced here

NATIONAL SHIMS used in the *Wisconsin Motors* powering the *'Cletracs'* with Comdr. *Byrd* at the South Pole.

NATIONAL
[*Double-Action ~ Non-Curling*]
SHIMS

—make motors easy to service *Anywhere*

Why handicap your sales force and shrink your market by making your motor hard to service? Use NATIONAL SHIMS on crankshaft and connecting rod bearings, and your motor can be serviced *instantly anywhere. All* the advantages of *any* method PLUS that quick, easy, always-available service so essential in extending markets and maintaining good will. More than 50 Mfrs. have already changed to NATIONALS. With or without *Anchored* Babbitt Tips (Patd.). Mail blueprints for prices and suggestions—

NATIONAL MOTOR BEARING CO., Inc., Mfrs., 460-470 Natoma St., San Francisco
Detroit—650 Beaubien Street - - *Waukegan, (Ill.)*— 444 Genesee St.

BCA

Straight Thrusts

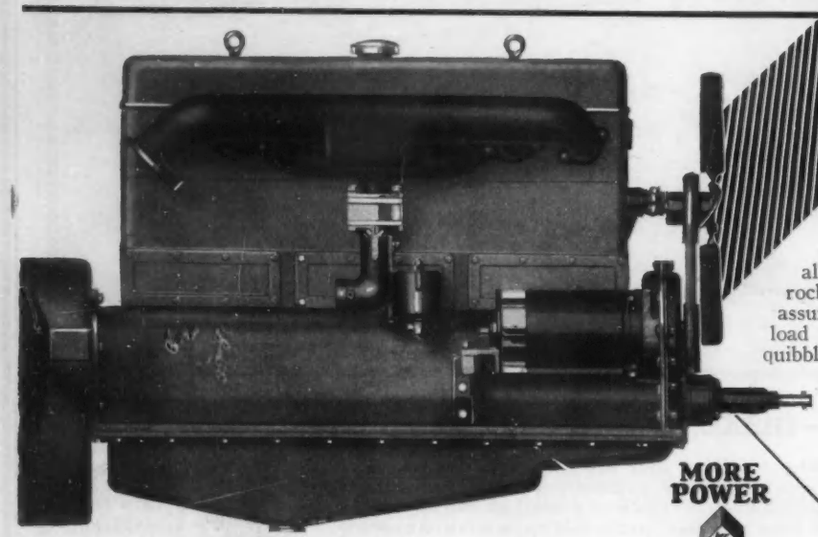
The Right Bearing for Every Car

are readily absorbed by B. C. A. Thrust Bearings. In the clutch release position they give unfailing service and ease of operation. In keeping with the demands of the present-day motor-buying public they add to this extreme quietness.

We will be glad to study the requirements of your car and give you the benefit of the advice of our automotive bearing experts.

Bearings Company of America
Lancaster, Pa.
Detroit, Mich. Office: 1012 Ford Bldg.

Consistent Performers



Wisconsin Motors are not temperamental "prima donnas"—marvels of power today and finicky non-performers tomorrow. They're consistently good—all the time. There is a positive, bedrock solidity about Wisconsin Motors that assures dependable performance even in overload service. They handle any job without quibbling or quitting.

The satisfaction given by any power-driven equipment naturally depends, to a great extent, upon the performance of the power unit. And that is the one best argument in favor of Wisconsin Motors.

MORE POWER PER CUBIC INCH

Wisconsin Motor Co.
Milwaukee, Wis.

Built in a full range of Sixes and Fours, from 20 to 150 H.P., for trucks, buses, tractors and industrial machinery.

Wisconsin CONSISTENT

CRANK DROP PARK GUARANTEED FORGED SHAFTS

Counterbalanced

CRANK SHAFTS

and

Heavy Die Forgings

THE PARK DROP FORGE COMPANY
Cleveland, Ohio

Hardness Tests Without Damage

In making hardness tests with Shore's Portable D Scleroscope, the inevitable permanent deformation is microscopic and in no way damages the salability of the product.

Used in testing hardest or softest metals, on pieces of any shape, size or thickness—capacity for 1000 tests per hour makes Shore's New Model D Portable Scleroscope practical for testing parts in production manufacturing.

Easily operated, portable, efficient.

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depends upon correct heat treatment. We offer Oil Tempered Springs treated scientifically in Electric Furnaces of absolute temperature control.

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and
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Five leading car manufacturers are using it as standard factory equipment (on both poppet and sleeve valve engines).

AS-KE AUTOMATIC FUEMER

ends starting troubles with their heavy drain on the battery and wear on the engine. By heating and vaporizing raw gas from the carburetor, it makes quick starting in cold weather an accomplished fact, even with cranking speed at 20 R.P.M., and at 3 volts ignition. It works *automatically* with the operation of the starter pedal. Uses very little current. Write for details. Demonstration at your convenience.

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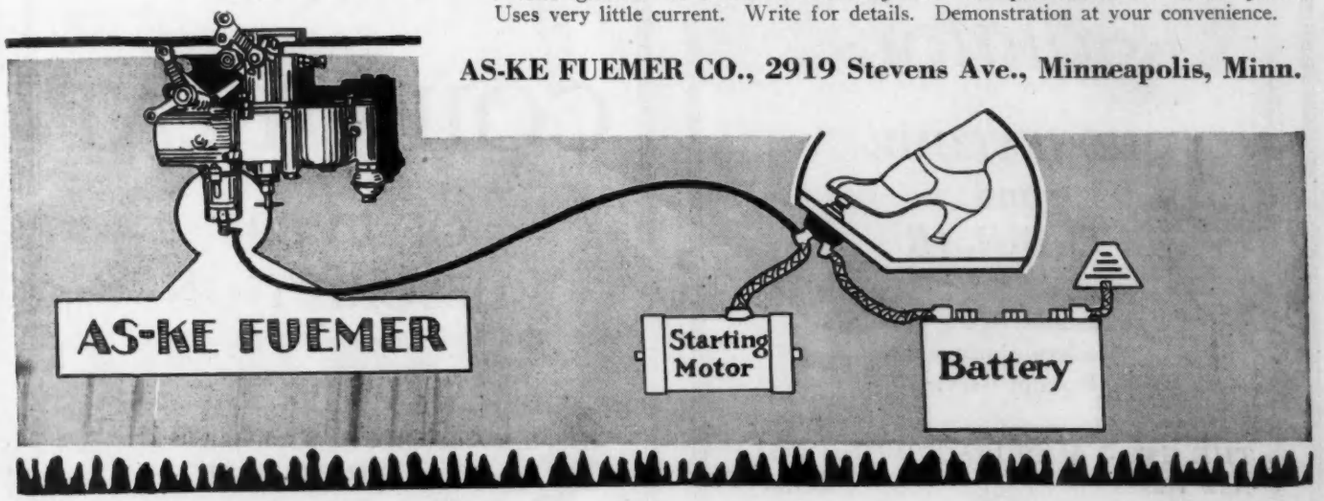

Curtiss Hawks used by Army and Navy Use Belden Radio Shielded Wire

The Curtiss Hawk Pursuit Planes in which Lieut. "Jimmy" Doolittle of the Army made the first outside loop and in which Lieut. Al Williams of the Navy duplicated this feat later, are equipped with Belden Radio Shielded Airplane Wire.

Belden Radio Shielded Airplane Wire is also used on the Curtiss Falcon, standard Observation and Attack type of the Army, as well as the Curtiss "Condor," giant Army night bombing plane.

It will pay you to investigate the outstanding merits of Belden Radio Shielded Airplane Wire.

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Consult Belden Airplane Engineers regarding specially designed airplane harnesses—either high or low tension—radio shielded or unshielded.

DEPENDABLE

In the operation of a complete and modern Felt Cutting Plant at Detroit, as well as four Felt Mills, the American Felt Company has provided the Automotive Industry with an entirely dependable source of supply. Quality, uniformity and quantity are under complete control from the raw wool to the automobile.

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Large Manufacturing Facilities
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FOR MECHANICAL PURPOSES

COIL AND FLAT

OF EVERY DESCRIPTION

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Standard Equipment on Majority of America's Better Cars

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Why Do You Clean Your Product?

THERE is a reason behind EVERY essential manufacturing operation. There is a reason for the existence of EVERY cleaning job. How familiar are you with the reason for each cleaning operation in your plant? For instance, is your objective

1—Speed and Accuracy of Production?
2—Ease and Accuracy of Inspection?
3—Quality of Product?
4—Satisfactory Performance of Product in Use?
5—To Reduce Scrap?
6—To Reclaim Waste Materials?

When cleaning operations are properly performed and standardized, the flow of production in a plant becomes uniform and controllable both as to Quality and Quantity.

You can make certain that your cleaning is on a controlled and money-saving basis if you will use Oakite materials and methods. Booklets and other information on request. No obligation, of course.

Oakite Service Men, cleaning specialists, are located in the leading industrial centers of the United States and Canada

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Industrial Cleaning Materials and Methods

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MAGNETIC FUEL LEVEL INDICATORS

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A HEAVY DUTY GAUGE FOR MOUNTING IN THE TOP, SIDE OR END OF FUEL TANKS

LEAK-PROOF
1½" PIPE THREADS

Listed as Standard by Underwriters' Laboratories

FLOAT TRAVEL 140° REGULAR, 75° SPECIAL

WE ALSO MAKE PRESSURE GAUGES OIL LEVEL INDICATORS RESERVE VALVES COMBINED LEVEL and PRESSURE GAUGES

Solid Die Cast Head Bright Nickel Plated. Porcelain Enamel Dial. Steel Pointer. Side Supports and Float Rod—Steel, Copper Plated. Gears—Die Castings. Center Shaft—Brass. Large Float, Positively Oil Proofed.

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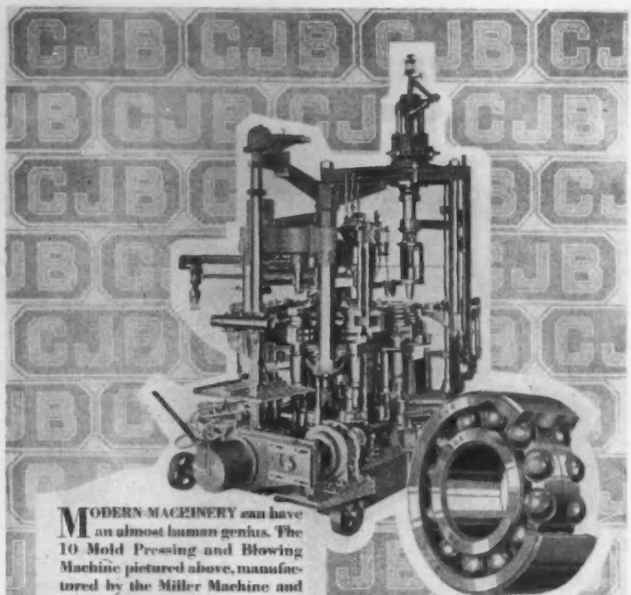

MODERN MACHINERY can have an almost human genius. The 10 Mold Pressing and Blowing Machine pictured above, manufactured by the Miller Machine and Mold Works of Columbus, Ohio, is such a machine. It turns out, in practically complete form, fruit and packer's jars, cylindrical ware, globes, shades, vases, and glass tumblers!

The finest ball bearings built are used in this Miller design

AHLBERG BEARING COMPANY
321 E. 29th Street, Chicago, Ill.
Branches in 34 Cities

"C. J. B" Double Row Ball Bearings of the type illustrated, are used in the above Miller machine. Twenty of these superior ball bearings are incorporated.

MASTER BALL BEARINGS

BOSSERT STAMPINGS

As in the first days of the Automobile and Truck, reliable stampings with dependable deliveries at competitive prices.

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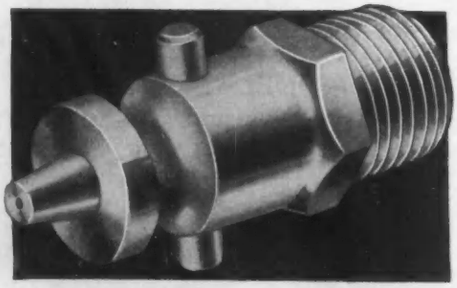
ADAMS SYSTEM WILL HELP SELL MORE CARS!



ADAMS
LUBRICATING NIPPLE
Fits ANY Grease Gun in General Use

ONE of the greatest strides forward ever made in scientific lubrication — three nipples in one! Makes it possible for any car to be served by *any make of grease gun or lubricating equipment*, at any service station, in any part of the world.

A masterpiece of scientific design—and a real boon to the car owner. Fits all types of Adams Grease Guns, including the new Push and Screw types. Widely endorsed by Engineers, Factories and Service Stations.

Samples Talk—Let us send you a few for your inspection and test. They will prove a revelation. Write for full particulars.

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WHEN you require cooperation in the design or other factors associated with the use of Springs, won't you take advantage of our special engineering resources?

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Practical Springmakers
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(Fully Equipped)
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BRISTOL CONN.

Barnes-made Springs
SPRINGS · ASSEMBLIES · SCREW MACHINE PARTS
STAMPINGS · SPRING WASHERS · COLD ROLLED SPRING STEEL

SMALL DROP FORGINGS

Forged and Trimmed Only or Machined Complete
Modern Heat Treating Facilities
For All Grades of Steel

ALSO

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Eagle Carriage Bolts	Wrought Washers
Cold Punched Nuts	Machine Bolts
Small Rivets	Plow Bolts
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> > >

The Columbus Bolt Works Co.
Columbus, Ohio

QUALITY :-: SERVICE

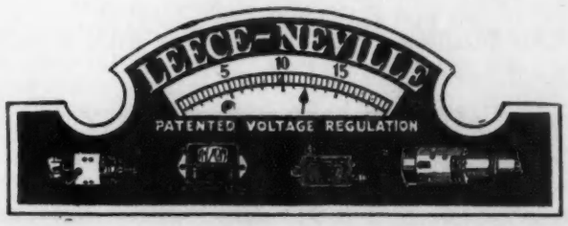
Voltage Regulation Minimizes Electric Maintenance

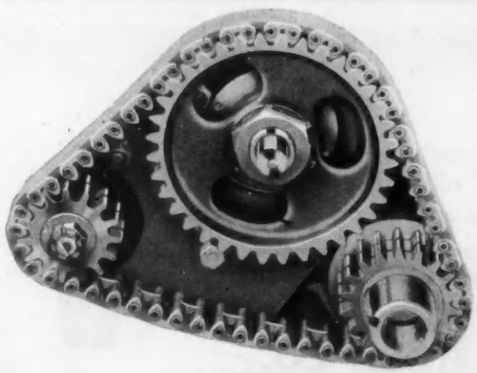
1. Battery cannot be overcharged.
2. The battery is charged only at the correct rate for its state of charge.
3. Battery will operate longer without requiring replenishing of electrolyte.
4. Life of battery greatly prolonged.
5. Lights can be operated direct from generator.
6. Loose connections will not cause lamp bulbs to burn out.
7. Makes most economical generator system.
8. Any Leece-Neville Voltage Regulated Generator can be used without battery.
9. Lamp life greatly prolonged.
10. Motor coaches fitted with Leece-Neville voltage regulated generators provide passengers with satisfactory illumination and safe transportation.

Leece-Neville Prestige is due solely to the excellence of Leece-Neville equipment

The proof of any pudding is still in the eating and the great prestige of Leece-Neville equipment for Voltage Regulation is entirely due to the fact that *it works* . . . It works, and does all that we say it does, because we have combined the highest type of electrical engineering with absolutely precise manufacturing methods. As a result, practically every aeroplane and an impressive percentage of all commercial vehicles boast Leece-Neville equipment. Write today for descriptive data and you will desire the same profit-paying equipment for your own vehicles.

LEECE-NEVILLE CO.
CLEVELAND, OHIO





THE
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SILENT TIMING CHAIN

Double Interior Engaging Links
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The new "Whitney" Silent Timing Chain has all the features essential and desirable in a timing chain.

Quietness and smoothness in action and long life.

The improved link form, in combination with the hollow split pin, accomplishes these desirable results.

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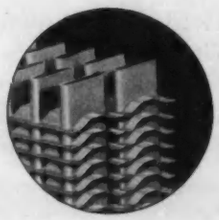
1 to 1000 H.P. OR MORE



ANY SIZE ANY TYPE

Modine
Turbotube RADIATORS

MODINE MANUFACTURING CO.
RACINE, WIS.

QUESTION AND ANSWER

The question is asked us by truck manufacturers: "Why do you not manufacture a rear axle of the same quality as your front?"—Our answer has always been that our entire manufacturing efforts are devoted to maintaining and marketing a quality Front Axle because this unit is as far removed in design and manufacture from the rear axle as a radiator is from a windshield.

One business—one purpose—a quality product.

SHULER AXLE COMPANY
Louisville Kentucky

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Flexible All-Metal Fuel Lines for Trucks, Tractors and Busses

Titeflex is all-metal.
Titeflex eliminates broken fuel lines.
Titeflex absorbs vibration within its own structure.
Titeflex is tight for the carrying of gasoline, oil and air.
Titeflex being flexible is easy to install, and speeds up a production line.

Complete Catalogue sent on request.

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WOOD SPOKE METAL FELLOE
WHEELS
For Use with Single and Dual Solid Tires

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WHEELS
For Use with Single and Dual Pneumatic Tires

1867 Hoopes, Bro. & Darlington, Inc. 1929
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The Product of America's Foremost Ball Plant.

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Ball Bearings
(annular and thrust)

Roller Bearings (tapered)

Let us figure with you.

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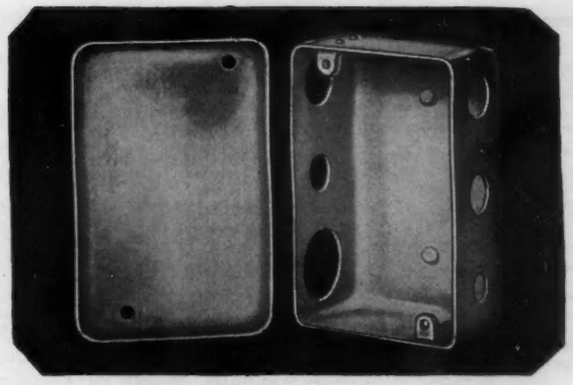
Ann Arbor, Michigan

Branches: Chicago, Brooklyn, N. Y.; San Francisco



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METAL STAMPINGS

WE USUALLY MAKE THEM IN LESS OPERATIONS THAT'S WHY OUR PRICES GET THE BUSINESS

FORGED STEEL RINGS and BANDS

FOR RUBBER - BOILER - RAILROAD SUGAR REFINING - FLYWHEEL GEARS ENGINEERING AND ALLIED INDUSTRIES

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AKRON, OHIO

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MOULDING SPECIALISTS

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Make fine lines in Color

JUST the pencils you need for marking blueprints, sketching, retouching, checking, figuring, underscoring, etc.

Can be sharpened in a pencil sharpener and easily erased.

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Asst No. 1116—12 Colors per box—$1.00
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American Pencil Co., 532 Venus Bldg., Hoboken, N. J.
Makers of the famous VENUS Pencils

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Aluminum Industries, Inc.
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Castings, Grey Iron
Link-Belt Co.

(*Continued on page 114*)

Manufacturers of Products Conforming to S.A.E. Specifications

Advertisers whose products conform to S.A.E. specifications are also listed in the S.A.E. Handbook List of Manufacturers, beginning on page 594, of the 1929 issue of the Handbook.

The addresses of companies listed in this index can be obtained from their current advertisements indexed on page 120.

Controlling the Unseen in Steel

View of part of New Departure's gigantic heat treating plant.

PHOTOMICROGRAPH of bearing steel after forging, etched with nitric acid and magnified 1,000 diameters.

THE same steel after normalizing and annealing. Showing fine spheroidized grain structure so important to strength.

AFTER forging, the next step in the preparation of the steel for New Departure Ball Bearings is to relieve all internal strains . . . to refine the grain and to soften the steel to a point where it may be readily machined.

The grain is refined by normalizing in the batteries of oil-fired furnaces shown above where a relatively high temperature is maintained uniform by the use of electric pyrometers.

After a precisely determined time the forgings are removed and allowed to cool in air. This operation removes the heterogeneous structure of the steel and puts it in the best possible condition for annealing.

Annealing is required to soften the steel and eliminate strains from forging. This heat treatment brings the forgings to a temperature just below the hardening or critical range of the steel and holds this temperature for a relatively long time.

Through special processes unique with this company the steel is spheroidized—or brought to a structure of minute spheres. By this method can New Departure's special analysis, high carbon chrome alloy steel be cut with relative ease without tearing.

Only by an intimate knowledge of metallurgy and the ability to control the unseen in steel are New Departure Ball Bearings produced with a uniform endurance unsurpassed elsewhere in industry.

New Departure Ball Bearings

The New Departure Manufacturing Co.

Bristol, Connecticut

Chicago · Detroit · San Francisco

115

INDEX TO ADVERTISERS' PRODUCTS

Castings, Malleable Iron
Link-Belt Co.
Timken Roller Bearing Co.

Castings, Permanent Mold
Aluminum Industries, Inc.

Castings, Steel
Clark Equipment Co.
Link-Belt Co.

Castings, Tin Alloy
Bohn Aluminum & Brass Corporation
Federal-Mogul Corporation

Cement, Rubber
Goodrich Rubber Co., B. F.

Chains, Block
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

Chains, Roller
Link-Belt Co.
Whitney Mfg. Co.

Chains, Silent
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

Chains, Timing and Automatic Adjustments
Link-Belt Co.

Channels, Window Glass
Dahlstrom Metallic Door Co.

Chucks
Bullard Co.

Clamps
Danly Machine Specialties, Inc.

Clamps, Hose
Schrader's Son, Inc., A.

Clamps, Wire and Tubing
Akron-Selle Co.

Cleaners, Air
Handy Governor Corporation

Cleaners, Metal
Oakite Products, Inc.

Clutches, Engine
Borg & Beck Co.
Brown-Lipe Gear Co.
Fuller & Sons Mfg. Co.
Long Mfg. Co.
Spicer Mfg. Corporation
Unit Corporation of America

Clutches, Power Transmission
Brown-Lipe Gear Co.
Link-Belt Co.

Cocks, Drain
Dole Valve Co.

Coils, Engine
Kingston Products Corporation

Coils, Ignition
Bosch Magneto Co., Inc., Robert
Kingston Products Corporation

Compounds, Phenolic Molding
General Plastics, Inc.

Compressors, Air
General Electric Co.
Wisconsin Motor Co.

Condensation Products
Bakelite Corporation
General Plastics, Inc.

Conduit, Flexible, Non-Metallic
General Electric Co.

Connecting-Rods
Bethlehem Steel Co.

Connecting-Rods, Aluminum
Aluminum Co. of America

Connections, Tire-Pump
Schrader's Sons, Inc., A.

Control Sets, Automotive
Brown-Lipe Gear Co.

Cooling Systems
G & O Mfg. Co.
Long Mfg. Co.

Couplings, Flexible
Spicer Mfg. Corporation

Couplings, Tubing
Dole Valve Co.
Titeflex Metal Hose Co.

Covers, Spring
Houde Engineering Corporation

Cranks, Starting
Thompson Products, Inc.

Crankshafts
Bethlehem Steel Co.
Park Drop Forge Co.
Union Switch & Signal Co.
Wyman-Gordon Co.

Cups, Grease
Adams Grease Gun Corporation
Link-Belt Co.

Cups, Priming
Dole Valve Co.

Cut-Outs
Kingston Products Corporation
North East Electric Co.

Cutters, Woodruff
Whitney Mfg. Co.

Cutters
Whitman & Barnes Corporation

Cutting Compounds
Oakite Products, Inc.

Die Makers' Supplies
Danly Machine Specialties, Inc.

Die Sets
Danly Machine Specialties, Inc.

Differentials
New Process Gear Co., Inc.

Discs, Universal Joint
Goodrich Rubber Co., B. F.

Door-Caps
Dahlstrom Metallic Door Co.

Drills, High-Speed
Clark Equipment Co.

Drills, Twist
Whitman & Barnes Corporation

Drop-Forgings
Bethlehem Steel Co.
Columbus Bolt Works Co.
Park Drop Forge Co.
Spicer Mfg. Corporation
Union Switch & Signal Co.
Wyman-Gordon Co.

Durometers
Shore Instrument & Mfg. Co.

Dynamometers, Chassis
General Electric Co.

Dynamometers, Electric Towing
Southwark Foundry & Machine Co.

Dynamometers, Engine
General Electric Co.

Engines, Industrial
Continental Motors Corporation
Hercules Motors Corporation
Wisconsin Motor Co.

Engines
Continental Motors Corporation
Hercules Motors Corporation
Waukesha Motor Co.
Wisconsin Motor Co.

Equipment, Arc-Welding
General Electric Co.

Explosion Recorder, Electric
Southwark Foundry & Machine Co.

Facings, Clutch
Russell Mfg. Co.

Felloe-Bands, Motor-Truck, Pneumatic Tire
Motor Wheel Corporation

Felt
American Felt Co.

Filters, Gasoline
Tillotson Mfg. Co.

Filters, Oil
Handy Governor Corporation
Kingston Products Corporation

Finish, Automobile Body
Arco Co.

Fire-Doors
Mahon Co., R. C.

Flanges, Hub
Bossert Corporation

Flanges, Tank
Rochester Mfg. Co., Inc.

Floors, Metal
Dahlstrom Metallic Door Co.

Forgings, Aluminum
Aluminum Co. of America
Bohn Aluminum & Brass Corporation

Forgings, Brass
Bohn Aluminum & Brass Corporation
Mueller Brass Co.

Forgings, Bronze
Bohn Aluminum & Brass Corporation

Forgings, Nickel Silver, and Bronze
Mueller Brass Co.

Frames, Pressed Steel
Smith Corporation, A. O.

Furnace, Electric
General Electric Co.

Fuses, Electric
General Electric Co.

Gages, Gasoline
Akron-Selle Co.
Nagel Electric Co., Inc.
Rochester Mfg. Co., Inc.

Gages, Inspection
Danly Machine Specialties, Inc.

Gages, Oil
Akron-Selle Co.
Nagel Electric Co., Inc.

Gages, Oil Level
Rochester Mfg. Co., Inc.

Gages, Oil Pressure
Rochester Mfg. Co., Inc.

Gages, Pressure, Electric Recording
Southwark Foundry & Machine Co.

Gages, Tire Pressure
Schrader's Son, Inc., A.

Gaskets, Automotive
Garlock Packing Co.

Gasoline
Ethyl Gasoline Corporation

Gearboxes, Power Take-Off
Brown-Lipe Gear Co.
Fuller & Sons Mfg. Co.
Unit Corporation of America

Gears, Bevel
Link-Belt Co.

Gears, Composition
General Electric Co.

Gears, Differential
New Process Gear Co., Inc.

Gears, Fibre
General Electric Co.

Gears, Reduction
Link-Belt Co.
Waukesha Motor Co.

Gears, Spur
Link-Belt Co.

Gears, Steering
Gemmer Mfg. Co.
Ross Gear & Tool Co.
Warner Corporation

Gears, Timing
Fibroc Insulation Co.
General Electric Co.

Gears, Transmission
Link-Belt Co.
Wyman-Gordon Co.

Generators (Standard Mountings)
Bosch Magneto Co., Inc., Robert
Electric Auto-Lite Co.
General Electric Co.
Leece-Neville Co.
North East Electric Co.

Governors
Handy Governor Corporation
Kingston Products Corporation

Grinders, Connecting-Rod Wrist-Pin Hole
Hutto Engineering Co., Inc.

Grinders, Cylinder
Hutto Engineering Co., Inc.

Grinders, Piston Wrist-Pin Hole
Hutto Engineering Co., Inc.

Grinding Compounds
Oakite Products, Inc.

Grommets, Rubber
Goodrich Rubber Co., B. F.

Guns, Grease
Adams Grease Gun Corporation

Guns, Oil
Adams Grease Gun Corporation

Handles, Door
Bohn Aluminum & Brass Corporation
Mueller Brass Co.

Head-Lamps
Bosch Magneto Co., Inc., Robert

Hoists, Electric
General Electric Co.

Holders, Die
Danly Machine Specialties, Inc.

Horns, Electric-Driven
Bosch Magneto Co., Inc., Robert
North East Electric Co.

Hose, Radiator
Goodrich Rubber Co., B. F.

Housings, Axle
Bossert Corporation
Pittsburgh Steel Products Co.
Smith Corporation, A. O.

Hubs, Wheel
Bossert Corporation
Budd Wheel Co.
Smith Corporation, A. O.

Hydraulic Machinery
Southwark Foundry & Machine Co.

Ignition-Generators
Bosch Magneto Co., Inc., Robert
North East Electric Co.

Ignition Units
Bosch Magneto Co., Inc., Robert
North East Electric Co.

Ingots, Aluminum
Aluminum Co. of America

Instruments, Precision Measuring
Norma-Hoffmann Bearings Corporation

Instruments, Scientific
Shore Instrument & Mfg. Co.

Insulation, Electric
Bakelite Corporation
General Electric Co.

Insulation, Molded
Bakelite Corporation
Belden Mfg. Co.

Joints, Ball-and-Socket
Thompson Products, Inc.

Joints, Universal
Mechanics Universal Joint Co.
Spicer Mfg. Corporation

Keys, Woodruff
Whitney Mfg. Co.

Lacing, Hood and Radiator
Russell Mfg. Co.

Lacquer, Pyroxylin
Arco Co.

Lamps, Electric Incandescent
General Electric Co.

Lamps, Mercury Vapor
Cooper Hewitt Electric Co.

Lathes, Chucking
Bullard Co.

Lathes, Turret
Bullard Co.

Lights, Spot
Bosch Magneto Co., Inc., Robert

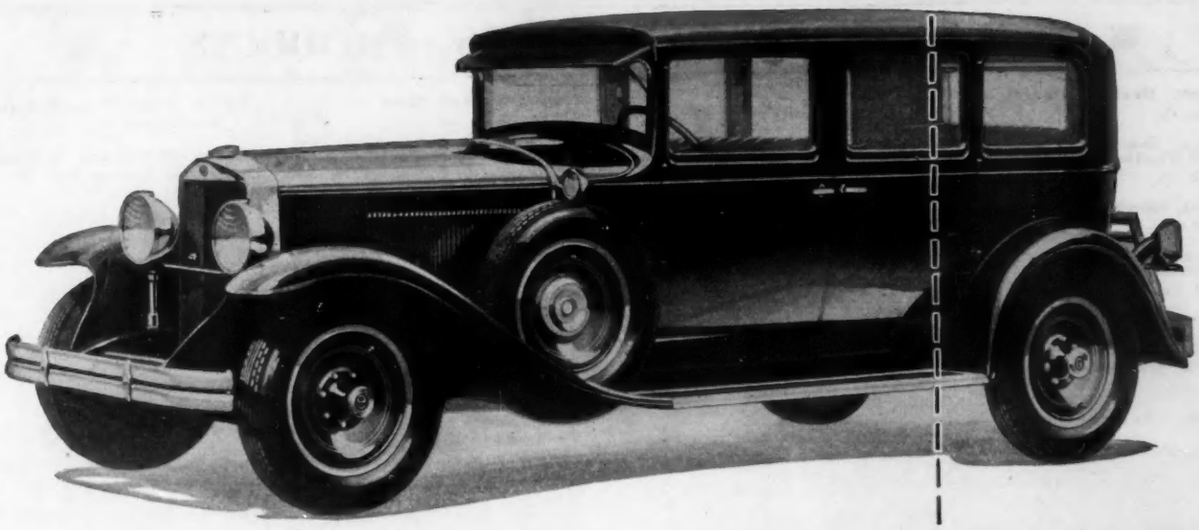
Links, Drag
Thompson Products, Inc.

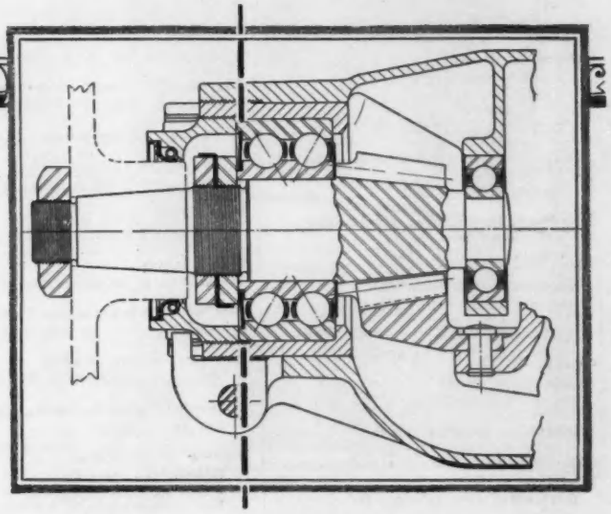
Lubricating Systems
Adams Grease Gun Corporation
Alemite Mfg. Co.
Bijur Lubricating Corporation

Machines, Automatic Chucking
Bullard Co.

Machines, Automatic Multiple-Spindle
Bullard Co.

(*Continued on page 116*)





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The Graham-Paige

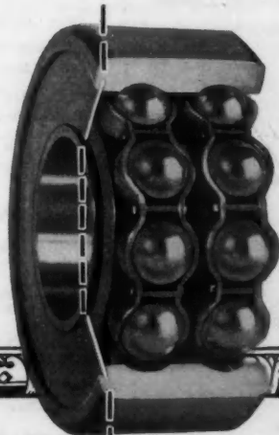
Model 837—5 Passenger Sedan, has

SRB Lubri-Seal

BALL BEARINGS

ON THE PINION

SRB Lubri-Seal Ball Bearings serve a combination of purposes on Graham-Paige pinion shafts... simplify mountings, exclude dirt, retain lubricant, increase useful life and decrease maintenance costs.



STANDARD STEEL AND BEARINGS INCORPORATED
Plainville DIVISION OF MARLIN-ROCKWELL CORPORATION *Connecticut*

Ball SRB Bearings

2919

INDEX TO ADVERTISERS' PRODUCTS

Machines, Boring (Vertical)
Bullard Co.

Machines, Boring, Turning and Facing (Vertical)
Bullard Co.

Machines, Chucking
Bullard Co.

Machines, Chucking and Turning
Bullard Co.

Machines, Milling
Whitney Mfg. Co.

Machines, Multiple Spindle
Bullard Co.

Machines, Power Transmission
Link-Belt Co.

Machines, Turret Automatic
Bullard Co.

Magnetos (Standard Mountings)
Bosch Magneto Co., Inc., Robert

Mats, Rubber
Goodrich Rubber Co., B. F.

Metal, Monel
International Nickel Co.

Mills, Vertical Boring and Turning
Bullard Co.

Molded Products, Phenolic Compound
General Plastics, Inc.

Moldings, Aluminum
Herron-Zimmers Molding Co.

Moldings, Cold-Drawn Steel
Dahlstrom Metallic Door Co.

Moldings, Steel
Herron-Zimmers Molding Co.

Moldings, White Metal
Herron-Zimmers Molding Co.

Moldings, Zinc
Herron-Zimmers Molding Co.

Molybdenum, Metallic
Vanadium Corporation of America

Mountings, Rubber
Goodrich Rubber Co., B. F.

Nails
American Steel & Wire Co.
Interstate Iron & Steel Co.
Parker-Kalon Corporation
Wheeling Steel Corporation

Nickel
International Nickel Co.

Nuts
Columbus Bolt Works Co.
Shuler Axle Co., Inc.

Oil-Pumps
Kingston Products Corporation

Oscillographs
Southwark Foundry & Machine Co.

Ovens, Drying
Mahon Co., R. C.

Ovens, Electric
General Electric Co.

Packing, Asbestos
Goodrich Rubber Co., B. F.

Packing, Automotive
Garlock Packing Co.

Packing, Water Pumps
Garlock Packing Co.

Paints, (See also Varnish, Enamel, etc.)
Arco Co.

Panels, Instrument
Dahlstrom Metallic Door Co.

Pencils, Drawing
American Lead Pencil Co.

Pinions
General Electric Co.

Pinions, Starting-Motor
Electric Auto-Lite Co.

Pins, Cotter
Shuler Axle Co., Inc.

Pins, King
Thompson Products, Inc.

Pins, Leader
Danly Machine Specialties, Inc.

Pins, Piston
Thompson Products, Inc.

Pins, Steel Dowel
Danly Machine Specialties, Inc.

Pipe Fittings
Dole Valve Co.
Mueller Brass Co.
Titeflex Metal Hose Co.

Pipe, Steel
Wheeling Steel Corporation

Piping, Blower Systems
Mahon Co., R. C.

Piping, Exhaust Systems
Mahon Co., R. C.

Pistons, Aluminum
Aluminum Co. of America
Aluminum Industries, Inc.
Bohn Aluminum & Brass Corporation

Piston-Rings
Piston Ring Co.

Pots, Fire
Clayton & Lambert Mfg. Co.

Powder, Aluminum Paint
Aluminum Co. of America

Power-Packs, Radio
Kingston Products Corporation

Powerplants, Industrial
Waukesha Motor Co.

Power Take-Offs
Brown-Lipe Gear Co.
Fuller & Sons Mfg. Co.
Unit Corporation of America

Primers
Arco Co.
Dole Valve Co.

Propeller-Shafts
Spicer Mfg. Corporation

Pumps, Starter
Kingston Products Corporation

Pyroscopes
Shore Instrument & Mfg. Co.

Radiators
G & O Mfg. Co.
Long Mfg. Co.
Modine Mfg. Co.

Reamers
Clark Equipment Co.
Whitman & Barnes Corporation

Regulators, Temperature
Dole Valve Co.

Relays, Cut-Out
North East Electric Co.

Retainers, Ball
Aetna Ball Bearing Mfg. Co.
Bearings Co. of America
Bossert Corporation

Ribbons, Fender
Dahlstrom Metallic Door Co.

Rims, Airplane Tire
Firestone Steel Products Co.

Rims, Pneumatic Tire
Bethlehem Steel Co.
Cleveland Welding Co.
Firestone Steel Products Co.
Motor Wheel Corporation

Rims, Solid Rubber Tire
Bethlehem Steel Co.
Firestone Steel Products Co.

Rings, Welded Steel
Akron-Selle Co.

Rivets, Steel
Columbus Bolt Works Co.
Interstate Iron & Steel Co.

Rod, Aluminum
Aluminum Co. of America

Rod, Brake
Thompson Products, Inc.

Rod, Brass
Mueller Brass Co.

Rod, Bronze
Mueller Brass Co.

Rod-Ends
American Nut & Bolt Fastener Co.
Columbus Bolt Works Co.
Kantlink Manufacturers.
Mansfield Lock Washer Co.
National Lock Washer Co.
Positive Lock Washer Co.
Reliance Mfg. Co.
Thompson Products, Inc.

Rod, Free-Cutting Brass
Mueller Brass Co.

Rod, Naval Brass
Mueller Brass Co.

Rod, Tie
Thompson Products, Inc.

Rod, Torque
Thompson Products, Inc.

Roller Bearings (See Bearings, Roller)

Roofing and Siding, Corrugated and Plain
New Jersey Zinc Co.
Wheeling Steel Corporation

Roofing and Siding, Zinc Alloy
New Jersey Zinc Co.

Roofing, Metallic
Mahon Co., R. C.
Wheeling Steel Corporation

Rubber, Strip
Goodrich Rubber Co., B. F.

Running-Boards
Smith Corporation, A. O.

Scleroscopes
Shore Instrument & Mfg. Co.

Screw-Machine Products
Akron-Selle Co.
Aluminum Co. of America
Barnes Co., Wallace
Dole Valve Co.
Link-Belt Co.
Mueller Brass Co.
New Process Gear Co., Inc.
Spicer Mfg. Corporation

Screws, Cap
Mechanics Universal Joint Co.
Shuler Axle Co., Inc.

Screws, Drive, Steel
Parker-Kalon Corporation

Screws, Wood
Interstate Iron & Steel Co.

Sets, Die
Danly Machine Specialties, Inc.

Shafts, Propeller
Pittsburgh Steel Products Co.
Spicer Mfg. Corporation

Shapes (Extruded Brass and Bronze)
Mueller Brass Co.

Sheets, Aluminum
Aluminum Co. of America

Sheets, Steel
Wheeling Steel Corporation

Sheets, Zinc
New Jersey Zinc Co.

Shelving, Steel
Cleveland Wire Spring Co.

Shock Absorbers, Friction
Hassler Mfg. Co.

Shock-absorbers, Hydraulic
Gabriel Snubber Mfg. Co.
Hassler Mfg. Co.

Shoes, Brake
Bossert Corporation

Sills, Body
Smith Corporation, A. O.

Snubbers
Gabriel Snubber Mfg. Co.

Speed Reducers
Link-Belt Co.

Speedometers
North East Electric Co.

Spokes, Wood, Motor Truck
Motor Wheel Corporation

Spokes, Wood, Passenger Car
Motor Wheel Corporation

Spark Plugs
Bosch Magneto Co., Inc., Robert

Spraying Booths
Mahon Co., R. C.

Springs, Air
American Steel & Wire Co.

Springs, Coiled
American Steel & Wire Co.
Barnes-Gibson-Raymond, Inc.
Cleveland Wire Spring Co.
Cook Spring Co.
Danly Machine Specialties, Inc.
Gibson Co., Wm. D.

Springs, Flat
American Steel & Wire Co.
Barnes Co., Wallace
Barnes-Gibson-Raymond, Inc.
Cleveland Wire Spring Co.
Cook Spring Co.
Gibson Co., Wm. D.

Springs, Leaf
Standard Steel Spring Co.

Sprockets, Block Chain
Whitney Mfg. Co.

Sprockets, Roller-Chain
Link-Belt Co.
Whitney Mfg. Co.

Sprockets, Silent-Chain
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

Stabilizers, Steering
Hassler Mfg. Co.

Stampings
Akron-Selle Co.
Barnes Co., Wallace
Bossert Corporation
Clayton & Lambert Mfg. Co.
Motor Wheel Corporation
Rochester Mfg. Co., Inc.
Smith Corporation, A. O.
Spicer Mfg. Corporation

Starter-Generators
North East Electric Co.

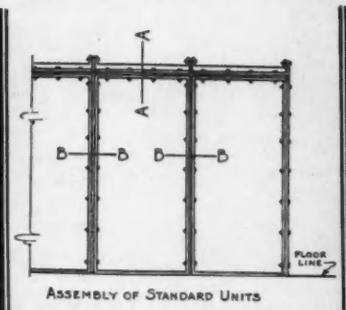
Starting-Motors (Standard Mountings)
Bosch Magneto Co., Inc., Robert
Electric Auto-Lite Co.
Leece-Neville Co.
North East Electric Co.

Steel, Alloy
Bethlehem Steel Co.
Central Alloy Steel Corporation
Donner Steel Co., Inc.
Illinois Steel Co.
Interstate Iron & Steel Co.
Timken Roller Bearing Co.
Wheeling Steel Corporation

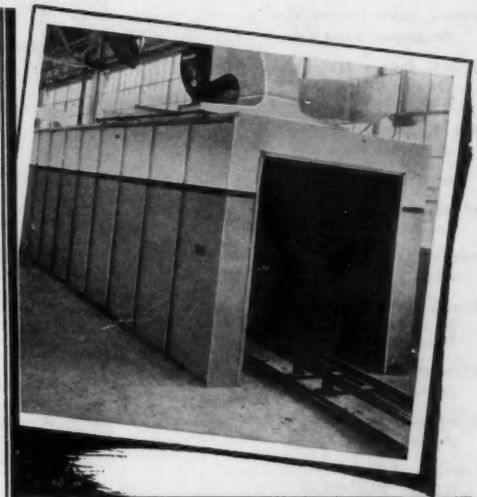
Steel, Carbon
Barnes Co., Wallace
Bethlehem Steel Co.
Central Alloy Steel Corporation
Donner Steel Co., Inc.
Illinois Steel Co.
Interstate Iron & Steel Co.
Timken Roller-Bearing Co.
Union-Drawn Steel Co.

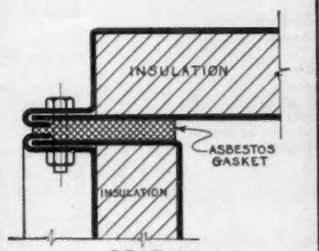
(*Continued on page* 118)

When Production Demands Re-arrangement of Equipment

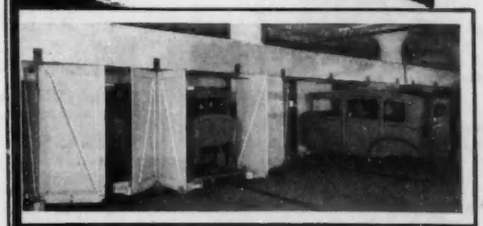


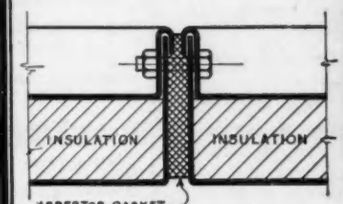
ASSEMBLY OF STANDARD UNITS





SECTION A-A





SECTION B-B

When business expansion necessitates rearrangement of equipment to facilitate new production systems, the advantages embodied in Mahon Drying Ovens are keenly realized. ¶The standard unit construction, with all insulation completely enclosed in metal, permits 100% salvage . . . . these ovens may be dismantled and re-erected in a new location, in any size or shape to meet individual requirements, without damage to the insulating material. ¶This feature is an important item to be considered in the selection of Drying equipment, particularly in plants where frequent changes in production lines are necessary. ¶Mahon Industrial Drying Ovens are fireproof and waterproof . . . . they are easily cleaned and require no maintenance whatever. ¶Consult Mahon engineers before you select your next Drying Oven . . . . let them show you the advantages of standard unit construction—write today.

THE R. C. MAHON COMPANY

DETROIT, MICHIGAN

Manufacturers of Industrial Drying Ovens, Spray Booths and Exhaust Stacks, Blow Pipe and Dust Collecting Systems

MAHON

INDUSTRIAL DRYING OVENS

BUILT FROM STANDARD INSULATED UNITS

INDEX TO ADVERTISERS' PRODUCTS

Steel, Cold Drawn
American Steel & Wire Co.

Steel, Electric Furnace
Timken Roller Bearing Co.

Steel, Leaf Spring
Central Alloy Steel Corporation

Steel, Molybdenum
Central Alloy Steel Corporation

Steel, Non-Corrosive
Bethlehem Steel Co.

Steel, Open Hearth
Timken Roller Bearing Co
Wheeling Steel Corporation

Steel, Rivet
Bethlehem Steel Co.
Illinois Steel Co.
Interstate Iron & Steel Co.

Steel, Special Analysis
Timken Roller Bearing Co.

Steel, Structural
Mahon Co., R. C.

Steel, Tool
Bethlehem Steel Co.
Timken Roller Bearing Co.

Strainers, Gasoline
Stromberg Motor Devices Co

Straps, Tire and Truck
Russell Mfg. Co.

Straps, Top
Russell Mfg. Co.

Studs, Ball
Thompson Products, Inc.

Supplies, Die Makers'
Danly Machine Specialties, Inc.

Switches, Starting
Electric Auto-Lite Co.
Leece-Neville Co.
North East Electric Co.

Systems, Fuel-Supply
Kingston Products Corporation

Tacks
American Steel & Wire Co.
Interstate Iron & Steel Co.

Tanks, Vacuum
Kingston Products Corporation

Tape, Insulated
Kerite Insulated Wire & Cable Co.

Tappets
Thompson Products, Inc.

Testers, Hardness
Shore Instrument & Mfg. Co.

Testing Equipment, Electric
Southwark Foundry & Machine Co.

Testing Machines, Torsion
Southwark Foundry & Machine Co.

Testing Machines, Universal
Southwark Foundry & Machine Co.

Thermostats
Dole Valve Co.

Timer-Distributors
Bosch Magneto Co., Inc., Robert
Electric Auto-Lite Co.
North East Electric Co.

Tires, Pneumatic
Clark Equipment Co.
Goodrich Rubber Co., B. F.

Tires, Solid
Clark Equipment Co.
Goodrich Rubber Co., B. F.

Tools, Forged Lathe
Bullard Co.

Torches, Blow
Clayton & Lambert Mfg. Co.

Torque-Arms
Bossert Corporation
Smith Corporation, A. O.

Torsion-Rod Assemblies
Thompson Products, Inc.

Transmissions
Brown-Lipe Gear Co.
Fuller & Sons Mfg. Co.
Mechanics Universal Joint Co.
Unit Corporation of America
Warner Corporation

Tubes, Inner
Goodrich Rubber Co., B. F.

Tubes, Torque
Pittsburgh Steel Products Co.

Tubing, Aluminum
Aluminum Co. of America

Tubing, Brass
Mueller Brass Co.

Tubing, Copper
Mueller Brass Co.

Tubing, Flexible Metal
Titeflex Metal Hose Co.

Tubing, Rubber
Goodrich Rubber Co., B. F.

Tubing, Steel
Pittsburgh Steel Products Co.
Smith Corporation, A. O.
Timken Roller Bearing Co.

Tubing, Windshield
Dahlstrom Metallic Door Co.

Tungsten, Metallic
Arco Co.
Vanadium Corporation of America

Turret Machines, Vertical
Bullard Co.

Universal-Joints
Mechanics Universal Joint Co.
Spicer Mfg. Corporation

Valves, Gasoline Needle
Dole Valve Co.

Valves, Poppet
Thompson Products, Inc.

Valves, Shut-Off
Dole Valve Co.

Valves, Thermostatic Water Control
Dole Valve Co.

Valves, Tire
Dill Mfg. Co.
Schrader's Son, Inc., A.

Vanadium Pentoxide
Vanadium Corporation of America

Varnishes, Finishing
Arco Co.

Varnishes, Phenolic Insulating
General Plastics, Inc.

Varnishes, Rubbing
Arco Co.

Washers
Bossert Corporation

Washers, Hardened and Ground
Aetna Ball Bearing Mfg. Co.

Washers, Lock
American Nut & Bolt Fastener Co.
Kantlink Manufacturers.
Mansfield Lock Washer Co.
National Lock Washer Co.
Positive Lock Washer Co.
Reliance Mfg. Co.
Shakeproof Lock Washer Co.
Shuler Axle Co., Inc.

Washers, Plain
Interstate Iron & Steel Co.

Washers, Spring
Barnes Co., Wallace

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Dole Valve Co.

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Russell Mfg. Co.

Webbing, Top
Russell Mfg. Co.

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Bossert Corporation

Welding Rod, Bronze
Mueller Brass Co.

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Hoopes, Bro. & Darlington, Inc.

Wheels, Expansion, Solid Tire
French & Hecht, Inc.

Wheels, Metal
Budd Wheel Co.
Clark Equipment Co.
Hoopes, Bro. & Darlington, Inc.
Smith Corporation, A. O.

Wheels, Pneumatic Tires, Single and Dual
French & Hecht, Inc.

Wheels, Pressed Steel Disc
Budd Wheel Co.
Clark Equipment Co.
Motor Wheel Corporation

Wheels, Steel, Industrial and Agricultural
French & Hecht, Inc.

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Firestone Steel Products Co.
Goodrich Rubber Co., B. F.

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Hoopes, Bro. & Darlington, Inc.

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Bethlehem Steel Co.

Wheels, Wire
Budd Wheel Co.

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Hoopes, Bro. & Darlington, Inc
Motor Wheel Corporation

Wheels, Wood-Spokes, Metal Felloes
Hoopes, Bro. & Darlington, Inc

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American Felt Co.

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Bosch Magneto Co., Inc., Robert

Windshield Wipers, Two Speed Electric
Stromberg Motor Devices Co.

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Aluminum Co. of America

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Zinc, Stick
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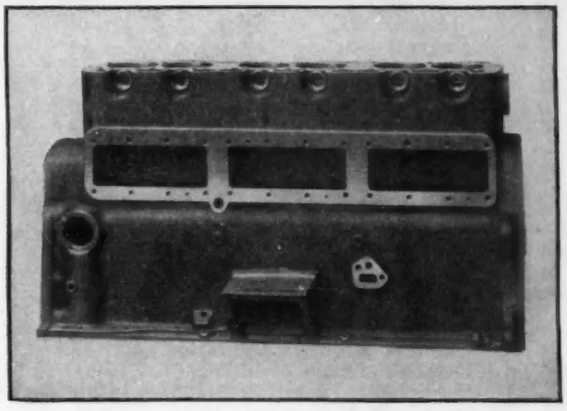

Nickel Cast Iron cylinder block produced by WISCONSIN MOTOR COMPANY, Milwaukee, Wis. Nickel 1.45%; chromium 0.45%. Hardness on cylinder bore 207-217 B H N.

WISCONSIN MOTOR CO. obtains greater wear-resistance with *Nickel Cast Iron* cylinder blocks

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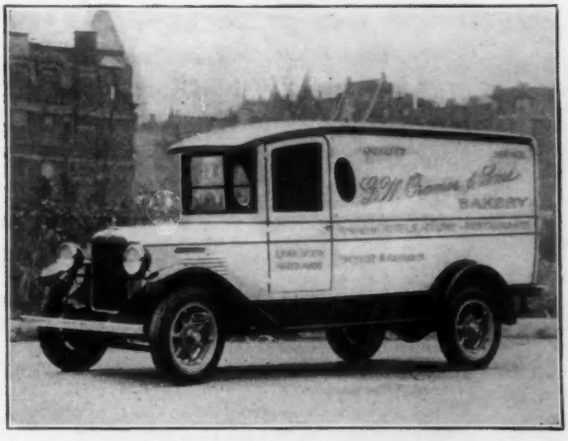
Uniformly high hardness... freedom from hard spots... greater toughness... these are the characteristics of Nickel Cast Iron which make this modern material particularly suited to automotive cylinder castings. This essential combination of properties provides improved wear-resistance along cylinder bores and helps prevent "hammering-in" of valve seats. It results in better operating efficiency and assures longer engine life. The dependable performance of these engines is indicated by the fact that such well known manufacturers as the Indiana Truck Corporation use Wisconsin Motors with Nickel Iron cylinder blocks for their high speed commercial trucks.



Indiana "Ranger" model 200 with Nickel Cast Iron cylinder block. Mfd. by INDIANA TRUCK CORPORATION, Marion, Indiana.

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Our foundry specialists will gladly discuss your casting problems with you

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK, N. Y.

INDEX TO ADVERTISERS

A

Adams Axle Co. 107
Adams Grease Gun Corporation ..108
Aetna Ball Bearing Mfg. Co. 42
Ahlberg Bearing Co. 108
Akron-Selle Co. 111
Alemite Mfg. Corporation 121
Aluminum Industries, Inc. 53
American Felt Co. 106
American Nut & Bolt Fastener Co. 45
American Pencil Co. 111
American Steel & Wire Co. 14
Arco Co. 79
As-Ke Fuemer Co. 105
Attwood Brass Wks., Inc. 44

B

Bakelite Corporation 29
Barnes Co., Wallace 108
Barnes-Gibson-Raymond, Inc. 102
Bearings Co. of America 103
Belden Mfg. Co. 106
Bendix Brake Co. 4
Bethlehem Steel Co. 33
Bijur Lubricating Corporation ... 9
Bishop & Babcock Sales Co. 28
Bohn Aluminum & Brass Corporation 72, 73
Borg & Beck Co. 23
Bosch Magneto Co., Inc., Robert.. 95
Bossert Corporation 108
Brown-Lipe Gear Co. 101
Budd Mfg. Co., Edward G. 39
Budd Wheel Co. 82
Buffalo Forge Co. 48
Bullard Co. 78

C

Carter Carburetor Co. 89
Central Alloy Steel Corporation... 8
Clark Equipment Co. ...59, 60, 61, 62
Clayton & Lambert Mfg. Co. 97
Cleveland Welding Co. 47
Cleveland Wire Spring Co. 105
Columbus Bolt Wks. Co. 109
Continental Motors Corp. 87
Cook Spring Co. 106

D

Dahlstrom Metallic Door Co. 81
Danly Machine Specialties, Inc. ..102
Delco Products Corporation 77
Dill Mfg. Co. 37
Donner Steel Co., Inc. 18

E

Electric Auto-Lite Co. 71
Electric Storage Battery Co. 40
Enduro Nirosta Steel 49, 50
Ethyl Gasoline Corporation 12

F

Fafnir Bearing Co. 76
Federal Bearings Co., Inc. 75
Federal-Mogul Corporation 1
Fibroc Insulation Co. 38
Firestone Steel Products Co. 65
Fuller & Sons Mfg. Co. 10

G

G & O Mfg. Co. 106
Garlock Packing Co. 26
Gemmer Mfg. Co. 98
General Electric Co. 74
General Plastics, Inc. 15
General Spring Bumper Co. 25
Gibson Co., Wm. D. 110
Goodrich Rubber Co., B. F. 99

H

Handy Governor Corporation 32
Harrison Radiator Corporation ... 6
Hassler Mfg. Co., Inc., Inside Back Cover
Hayes Body Corporation 70
Hercules Motors Corporation 41
Herron-Zimmers Moulding Co. ...111
Hoopes, Bro. & Darlington, Inc. ..110
Hoover Steel Ball Co. 111
Houde Engineering Corporation .. 68
Houdaille-Hershey Corporation....107
Hutto Engineering Co., Inc. 43
Hyatt Roller Bearing Co. 7
Hydraulic Brake Co. 66

I

Illinois Steel Co. 57
International Nickel Co., Inc.—67, 119
Interstate Iron & Steel Co. 36

K

Kantlink Manufacturers 45
Kerite Insulated Wire & Cable Co., Inc. 17
Kingston Products Corporation .. 92

L

Leece-Neville Co. 109
Link-Belt Co. 122
Long Mfg. Co. 80

M

McCord Radiator & Mfg. Co. 21
Mahon Co., R. C. 117
Mansfield Lock Washer Co. 45
Marvel Carbureter Co. 100
Mechanics Universal Joint Co. ... 34
Modine Mfg. Co. 109
Morse Chain Co. 64
Motor Wheel Corporation 2
Mueller Brass Co. 86

N

Nagel Electric Co. 84
National Lock Washer Co. 45
National Motor Bearing Co., Inc...103
New Departure Mfg. Co. 113
New Jersey Zinc Sales Co. 58
New Process Gear Co., Inc. 107
Norma-Hoffman Bearings Corporation 30

O

Oakite Products, Inc. 107

P

Park Drop Forge Co. 104
Parker-Kalon Corporation 22, 96
Piston Ring Co. 19
Pittsburgh Steel Products Co. 63
Positive Lock Washer Co. 45

R

Reliance Manufacturing Co. 45
Richardson Co. 90
Rochester Mfg. Co. 107
Ross Gear & Tool Co. 93
Russell Mfg. Co. 83

S

S K F Industries, Inc. 91
Shakeproof Lock Washer Co. 56
Shore Instrument & Mfg. Co. 104
Shuler Axle Co. 110
Smith Corporation, A. O. 11
Southwark Foundry & Machine Co. 20
Spicer Mfg. Corporation 18
Standard Steel & Bearings, Inc. ..115
Standard Steel Spring Co. 118
Stewart-Warner Speedometer Corporation 31
Strom Bearings Co. 94
Stromberg Motor Devices Co. 27

T

Thompson Products, Inc. 54, 55
Tillotson Mfg. Co. 5
Timken Roller Bearing Co. 51
Titeflex Metal Hose Co. 110

U

Union Switch & Signal Co. 24
Unit Corporation of America 10

V

Vanadium Corporation of America 85

W

Warner Corporation 107
Watson Co., John Warren Inside Front Cover
Waukesha Motor Co. 52
Westinghouse Air Brake Co..... 69
Wheeling Steel Corporation 88
Whitman & Barnes 35
Whitney Mfg. Co. 109
Willard Storage Battery Co. 46
Wisconsin Motor Co. 104
Wyman Gordon 16

The Index to Advertisers' Products is given on pages 112, 114, 116, and 118

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CENTRALIZED CHASSIS LUBRICATION THAT IS TRULY 100% AUTOMATIC AND CONTINUOUS

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ALEMITE, world leader in high pressure lubrication, offers a new and outstanding development of importance to every automotive engineer and manufacturer—the new Alemite Continuous Automatic Chassis Lubrication System.

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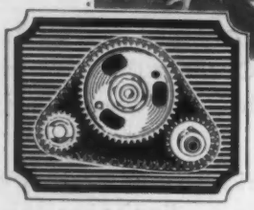

LINK-BELT Automotive Silent Chain Drives are quieter today than they were five years ago. In fact, they are better today than they were last year. They will be even better in the not too distant future.

Why? Because LINK-BELT is constantly improving every element that enters into design, construction and quantity production manufacture.

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Action either way *independently*

adjustable from outside of housing

in the new HASSLER HYDRAULIC

Showing how adjustment is made, outside the housing. Compression and rebound control are independently adjusted.

THERE are five distinctive features of the new Hassler Hydraulic Shock Absorber.

1. The car manufacturer's engineers can work out accurate adjustments at the factory for their particular car.

2. Further adjustment can be made from the outside of the housing, to please the car owner's fancy. Time: 3 minutes.

3. Adjustment of compression control can be made independently, without affecting control of rebound, and vice versa. Make your own ratio.

4. The port holes are of such size and the oil required is of such quality that the effect of even the coldest weather on the Hassler Hydraulic Shock Absorber is practically negligible. For example, comparative tests show that at a temperature of 5 below zero there is a difference of only 1¼ seconds on the first stroke, reduced to less than 1 second on the second stroke, while at the third stroke the action is normal. In other words, by the time the car is backed out of the garage the Hassler Hydraulic Shock Absorbers are functioning with mid-year efficiency.

Note the slot, divided into two parts. The upper part is the rebound control valve. The lower controls compression. The sleeve can be turned separately, changing rebound control without affecting compression. The inside valve can also be turned separately, changing compression control without affecting rebound.

5. The emulsion of air and oil, inevitable in any hydraulic shock absorber, has been utilized as an aid in producing remarkable softness of action.

Important as these five features are, they are by no means the whole story on the Hassler Hydraulic Shock Absorbers, nor the only reasons why you should investigate further.

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